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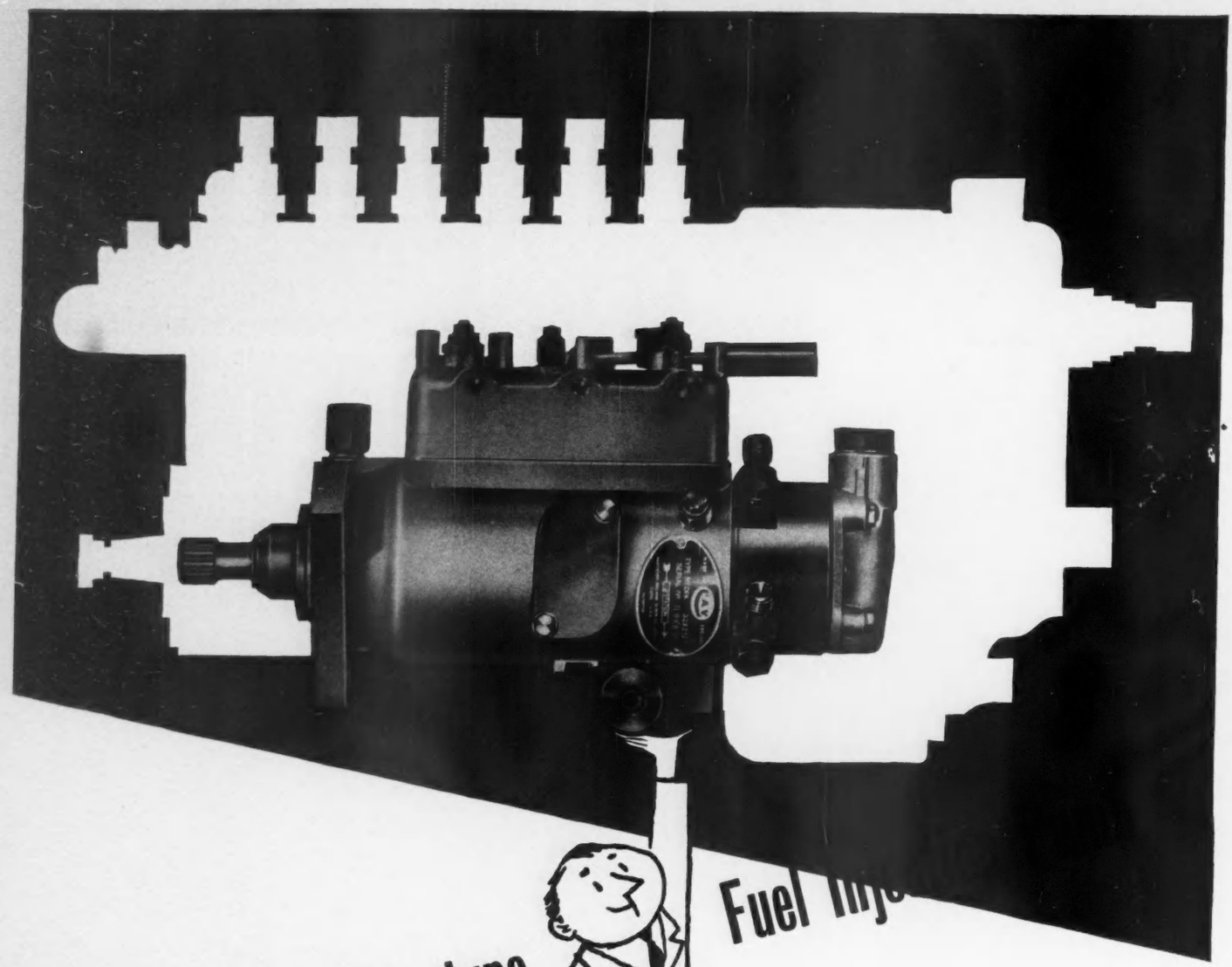

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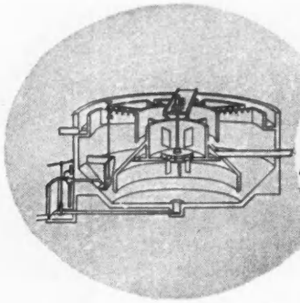

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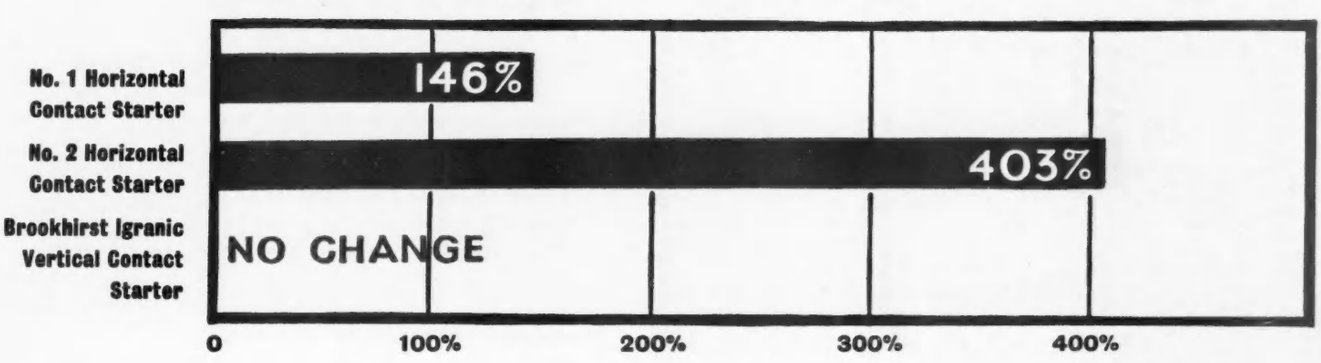

A Brookhirst Igranic motor starter with vertical contacts was tested in a standard dust chamber along with two starters with horizontal contacts.

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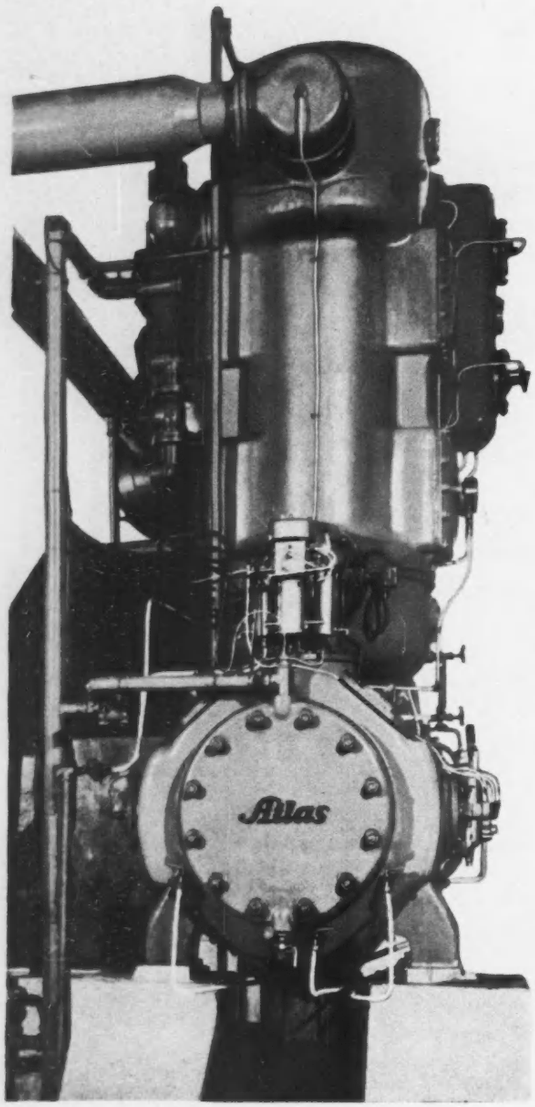

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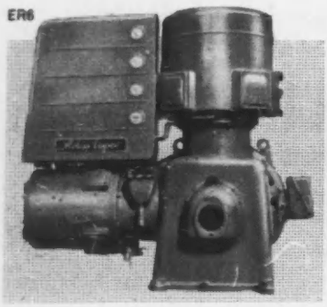

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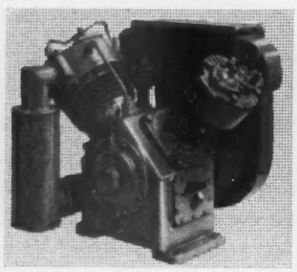

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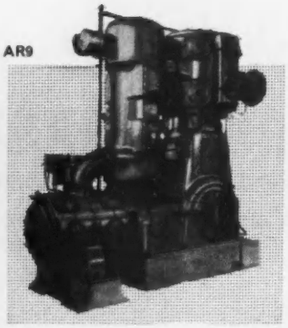

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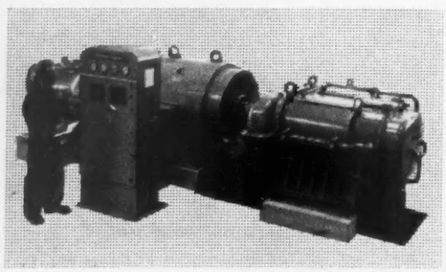

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17 June 1960

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Cover Picture

The growing points or spearheads in current machine-tool development are the subject of a group of special articles beginning this week. They are illustrated by freehand sketches such as an engineer might prepare for his own reference. The cover picture shows an automatic set-up used in the manufacture of high grade watch components. (*Nurnberg photograph for* ENGINEERING.)

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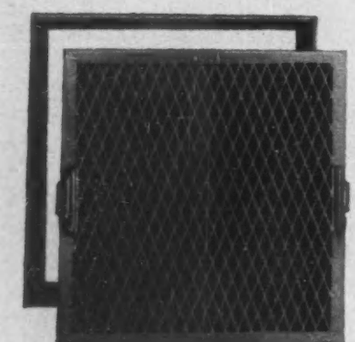
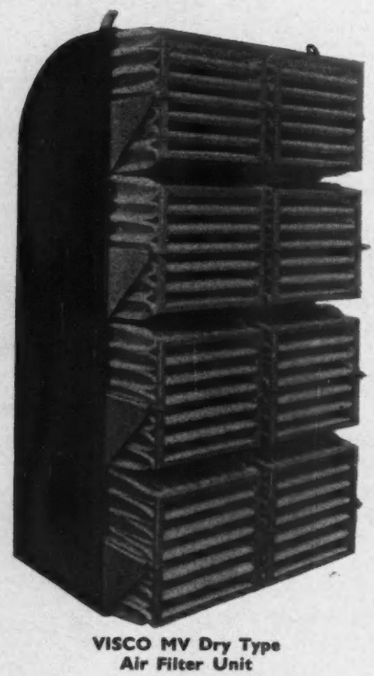


VISCO KM Oil Wetted Type Air Filter



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2. THE DIRECTOR, RAILWAY STORES, MINISTRY OF RAILWAYS (RAILWAY BOARD), STATE ENTRY ROAD, NEW DELHI.
3. THE DIRECTOR, INDIA SUPPLY MISSION, 2536, MASSACHUSETTS AVENUE, N.W. WASHINGTON 8 D.C.

TENDERS will be received by the DIRECTOR, RAILWAY STORES RAILWAY BOARD, STATE ENTRY ROAD, NEW DELHI, up to 12.00 hours on the 15th JULY, 1960, and opened in the office of the Railway Board on State Entry Road, New Delhi, on the same day. C 313

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TENDER REF. NO. 18001/60/BMB/HAL

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Applications for tender should specify the above reference. C 312

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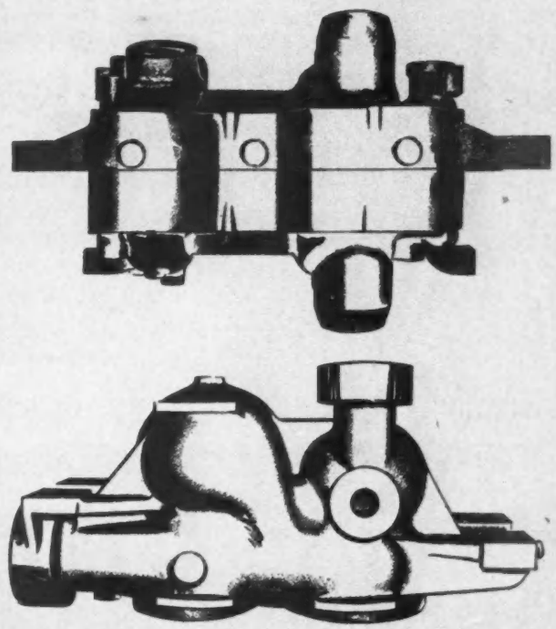

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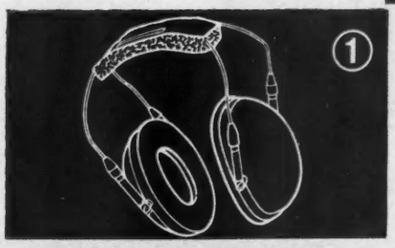

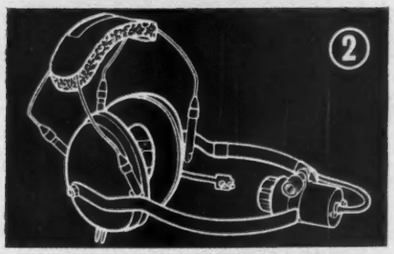

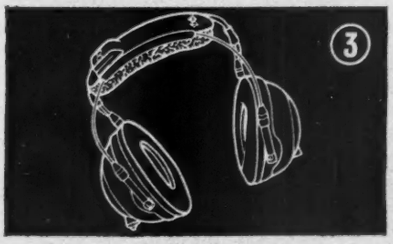

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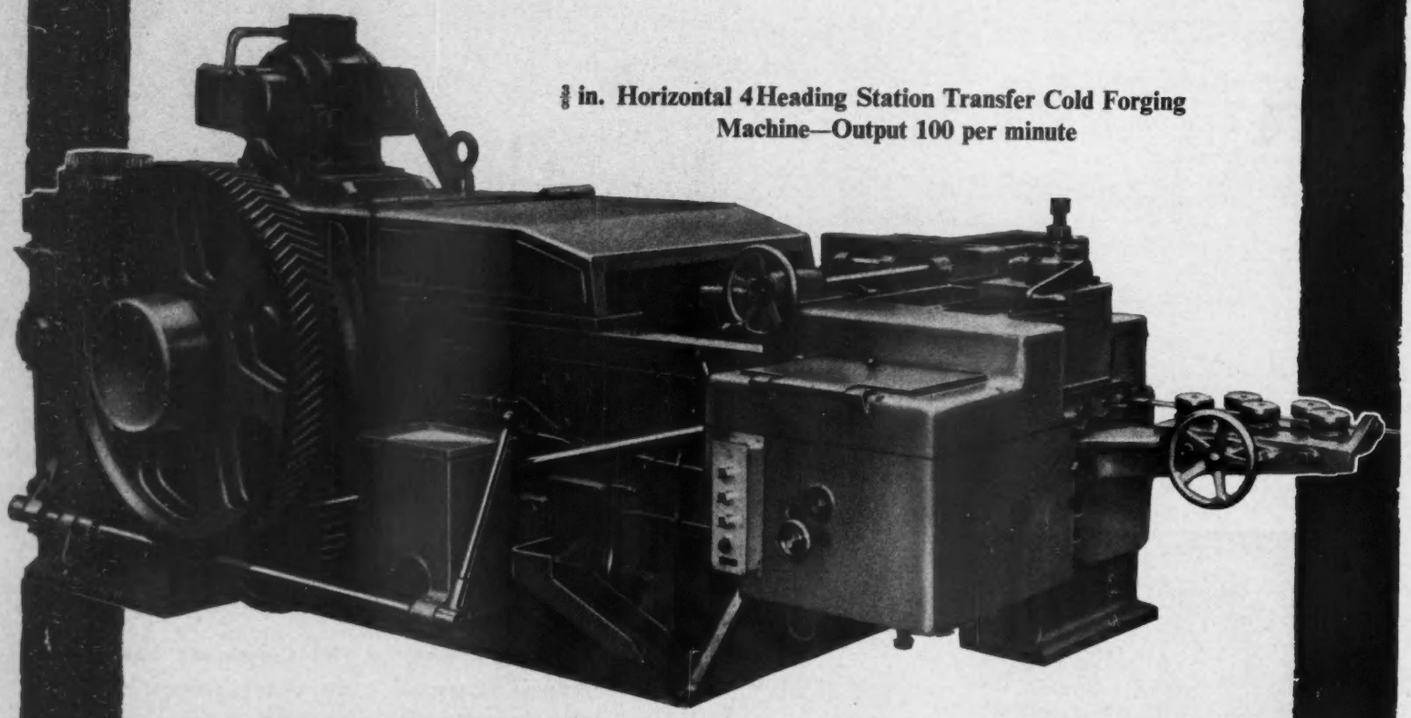

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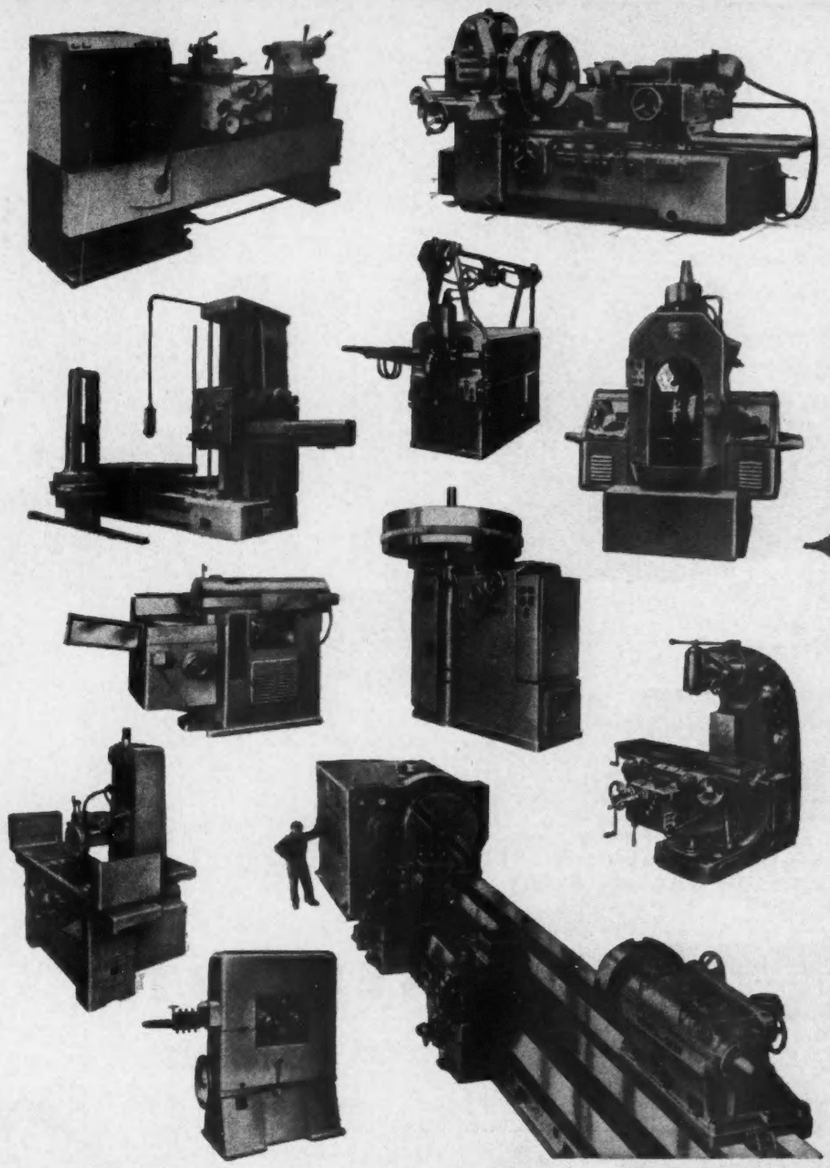

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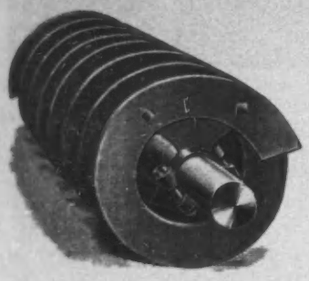

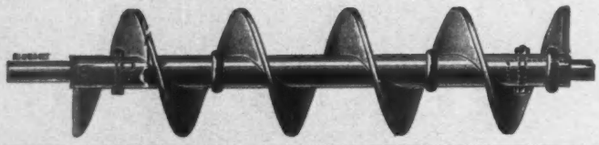

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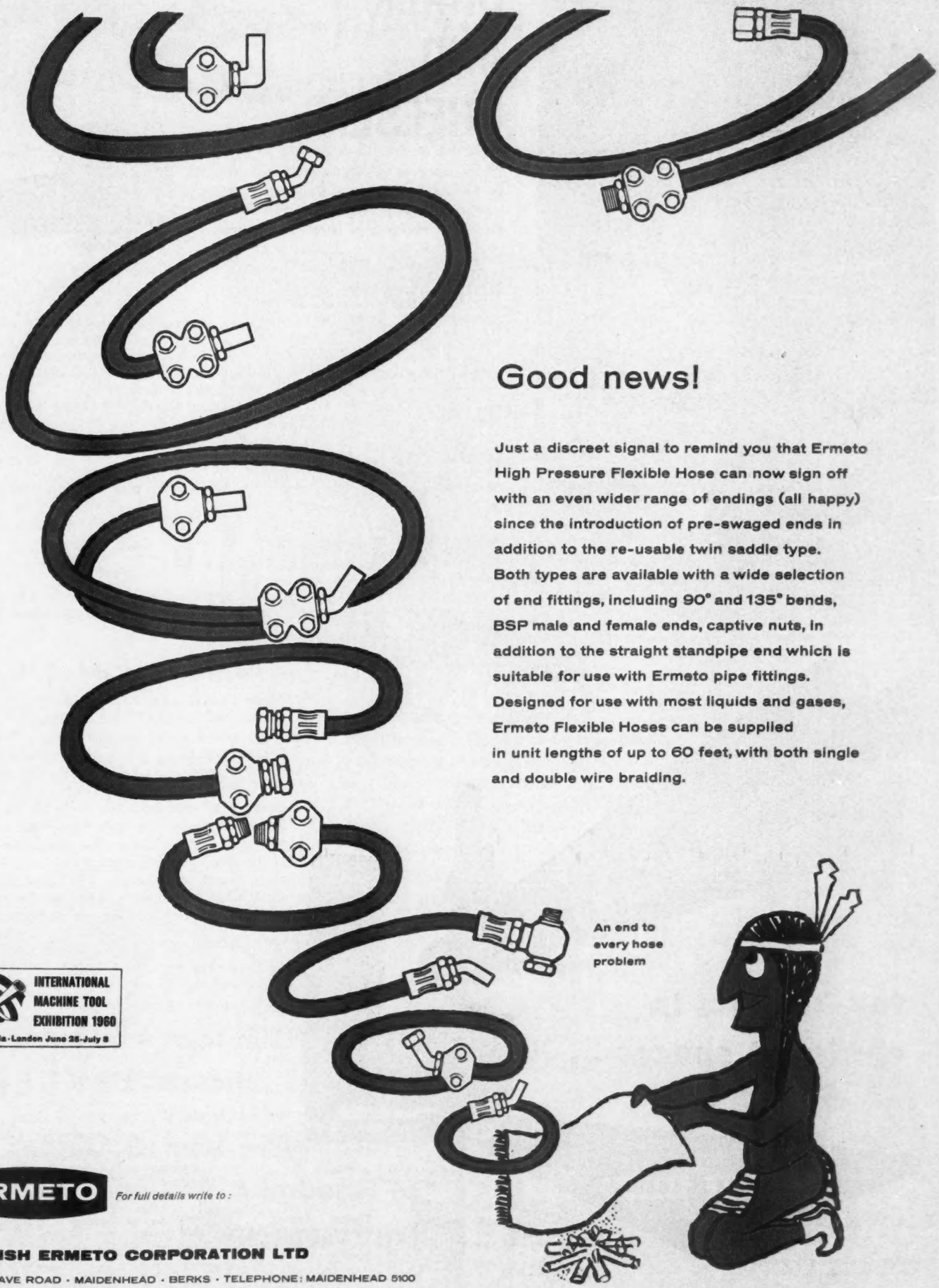

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Just a discreet signal to remind you that Ermeto High Pressure Flexible Hose can now sign off with an even wider range of endings (all happy) since the introduction of pre-swaged ends in addition to the re-usable twin saddle type. Both types are available with a wide selection of end fittings, including 90° and 135° bends, BSP male and female ends, captive nuts, in addition to the straight standpipe end which is suitable for use with Ermeto pipe fittings. Designed for use with most liquids and gases, Ermeto Flexible Hoses can be supplied in unit lengths of up to 60 feet, with both single and double wire braiding.

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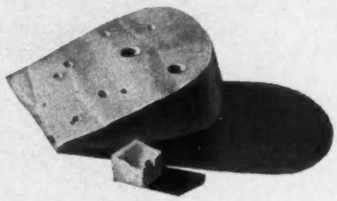
CHALK AND CHEESE



When it comes to coping with drainage problems the difference between a conventional suction pump and the Sumo Drainage Pump is as great as the proverbial one between chalk and cheese.

SUMO HURRIES SLURRIES

The difference is especially marked when, for example, water is thickened by the chalk and lime slurries encountered in large water-softening plants or by the silt to be found on building sites. The Sumo Drainage Pump operates equally well whether fully submerged or "on snore", needs no supervision whatever, and remains unperturbed by heavy concentrations of solid matter.
In the instance illustrated here the solids dealt with by the Sumo Pump represented 73% of the total volume passed.

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Hard cheese, in our opinion, if you're having to cope with a drainage problem with anything less efficient than a Sumo.

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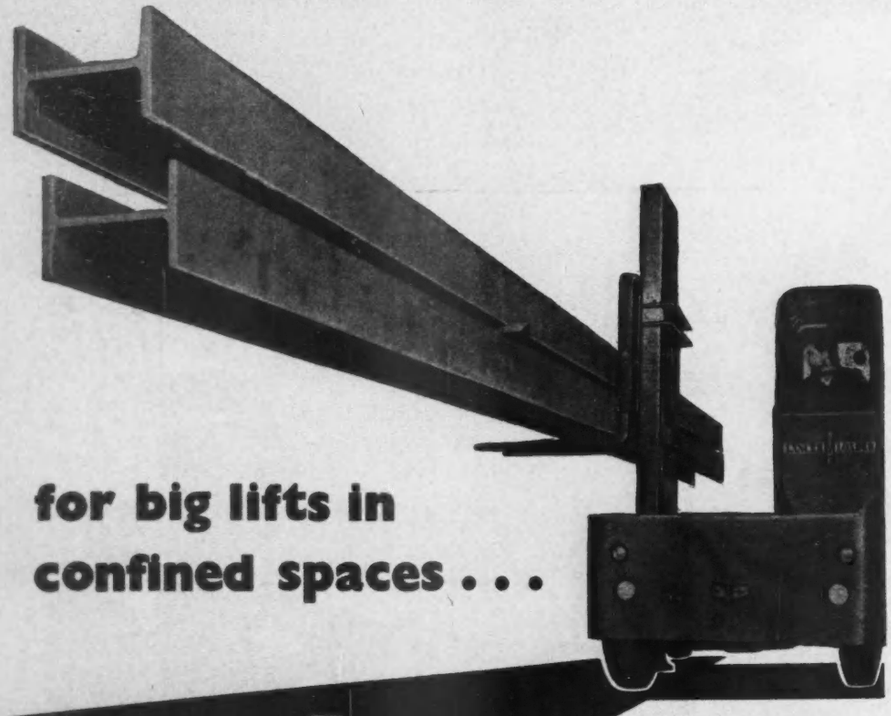

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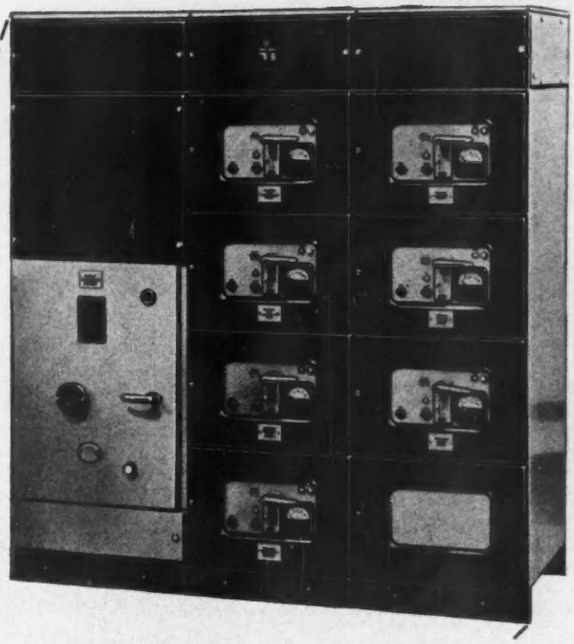
Stelvetite-plastic bonded to steel-has put a new face on Baldwin and Francis Switchgear Panels



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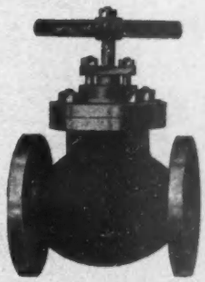

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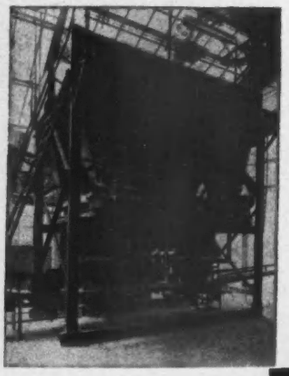

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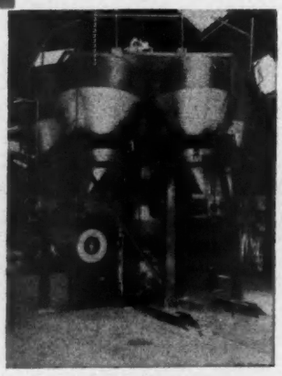

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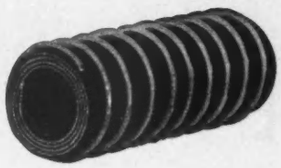

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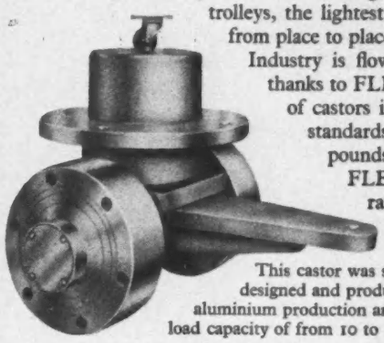
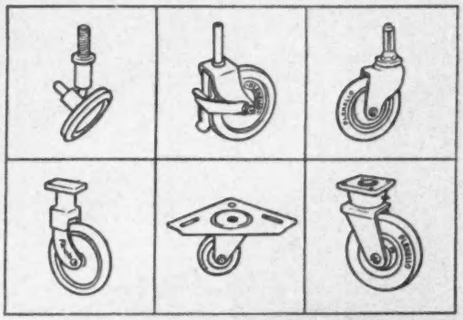


This castor was specially designed and produced for aluminium production and has a load capacity of from 10 to 12 tons.



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The repair was completed in 6 days. The owners saved hundreds of pounds in time and on cost of replacement.

Sailed as Scheduled . . .

A South American cargo steamer held up in The Surrey Docks, with a fractured stuffing-box in its marine engine, avoided the heavy dock dues and penalties by calling in a Barimar "Flying Squad" which completed a *guaranteed* repair in record time.

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The largest Granite Crusher in Great Britain had broken down. It was at the top of a 1,500 ft. mountain in North Wales. Work came to a standstill. Barimar was sent for and Barimar *guaranteed* to repair and strengthen the side-member of the Crusher *in situ*. A Barimar "Flying Squad" left immediately, working practically day and night until the job was finished within the contract time of six weeks. Then, the Crusher resumed work—24-hours a day—to catch up with the arrears, this was truly a magnificent test for this Barimar Record Repair.

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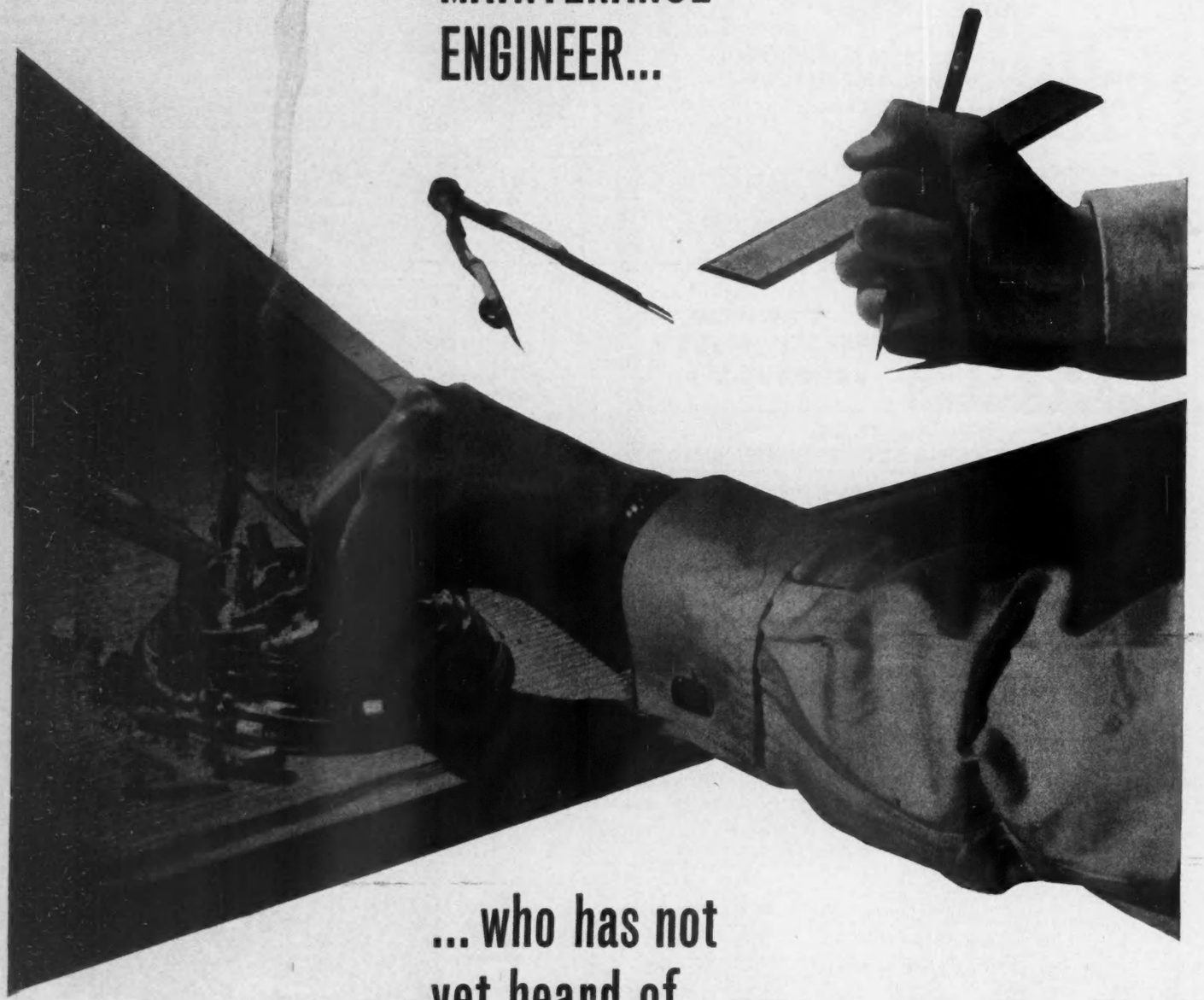

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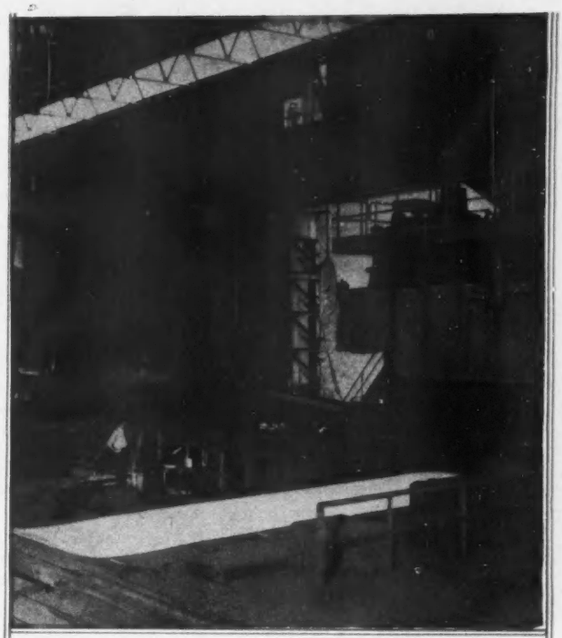

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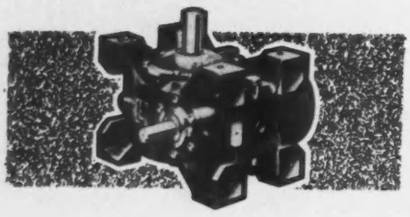

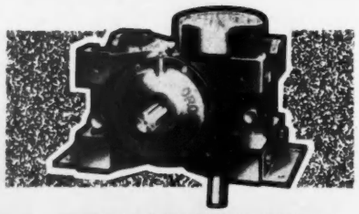

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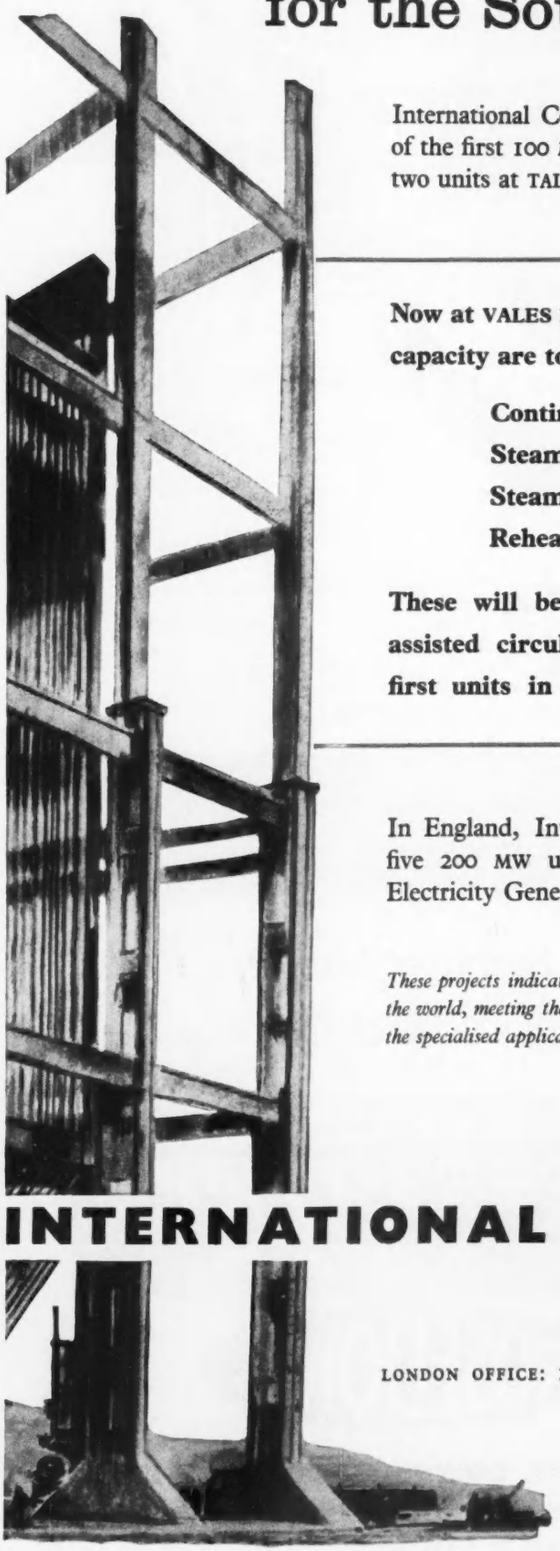

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Steam Temperature : 1,055 F
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These will be the first high capacity controlled and assisted circulation boiler units in Australia and the first units in the country to employ a reheat cycle.

◀ 200MW

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◀ 550MW

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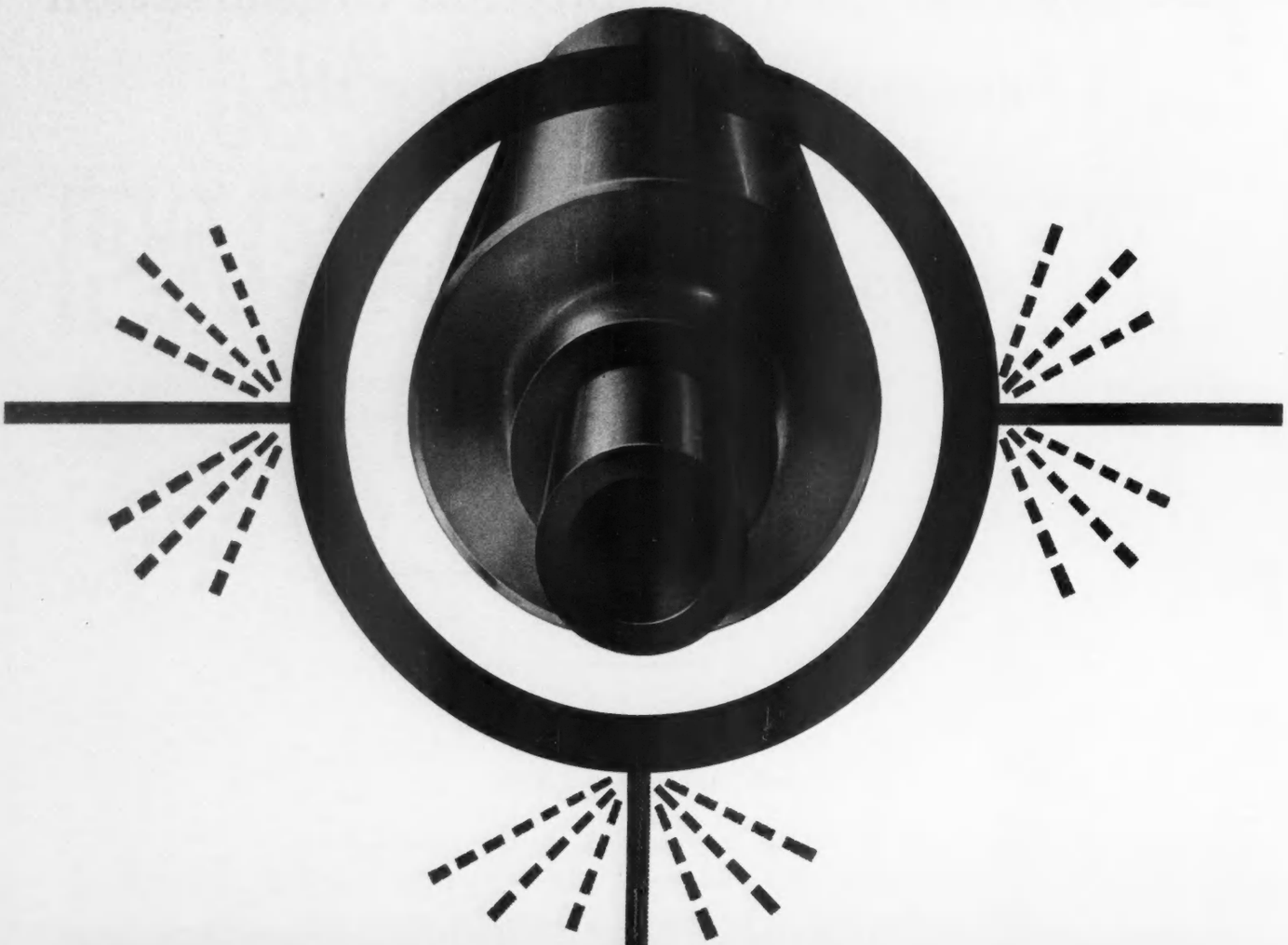

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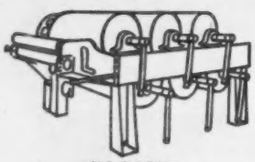

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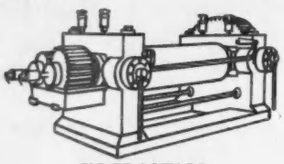

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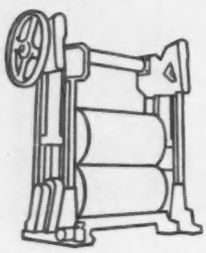

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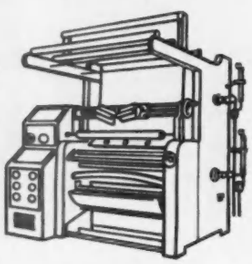

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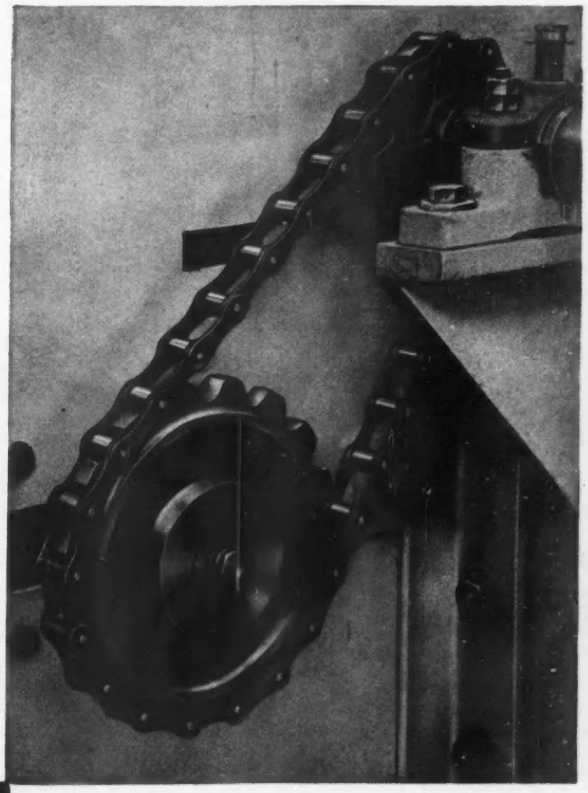

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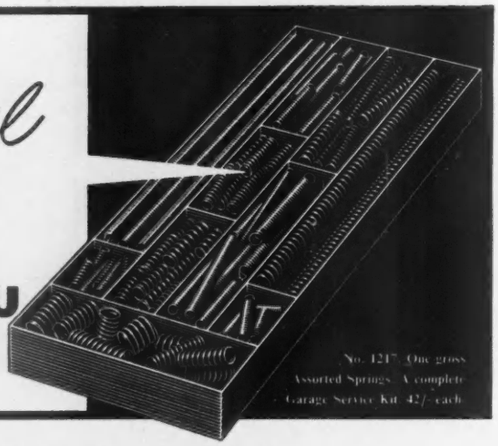

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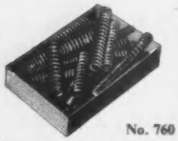
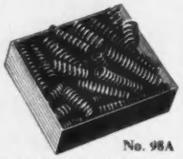
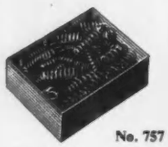
No. 1200
Three dozen Assorted Light Expansion Springs, suitable for carburettor control, etc. 13/6.



No. 760
Three dozen Assorted Light Compression Springs. 1" to 4" long, 22 to 18 S.W.G., ¼" to ½" diam. 6/6.



No. 98A
Three dozen Assorted 1" to 4" long, ½" to ¾" diam., 19G to 15G. 5/6.



No. 757
Extra Light Compression, 1 gross Assorted, ¼" to ⅜" diam., ½" to 2½" long, 27 to 19 S.W.G. 15/-.

No. 753
Three dozen Assorted Light Expansion ½" to ¾" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6.

No. 758
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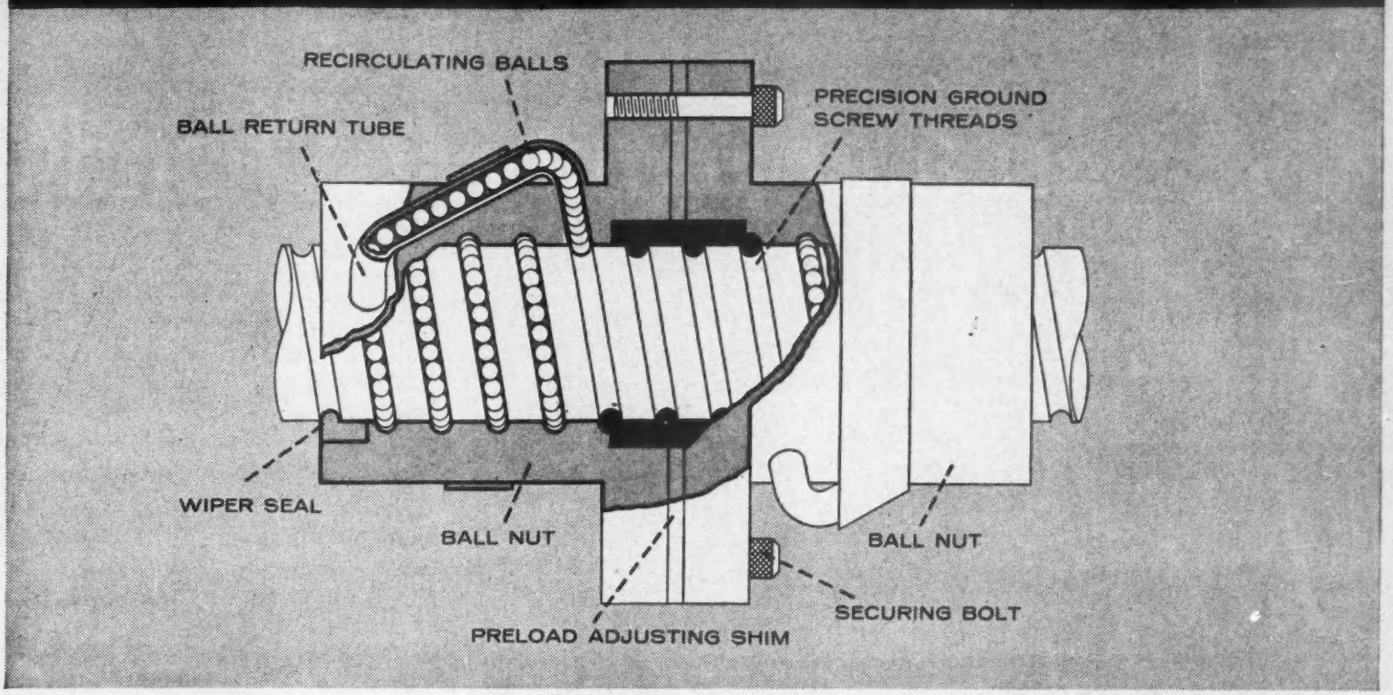

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Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

* *Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

For further information please write to:

J. B. STARKY, SALES MANAGER (BEAVER PRODUCTS DIVISION), BRISTOL SIDDELEY ENGINES LIMITED, PO BOX 17, COVENTRY, ENGLAND.

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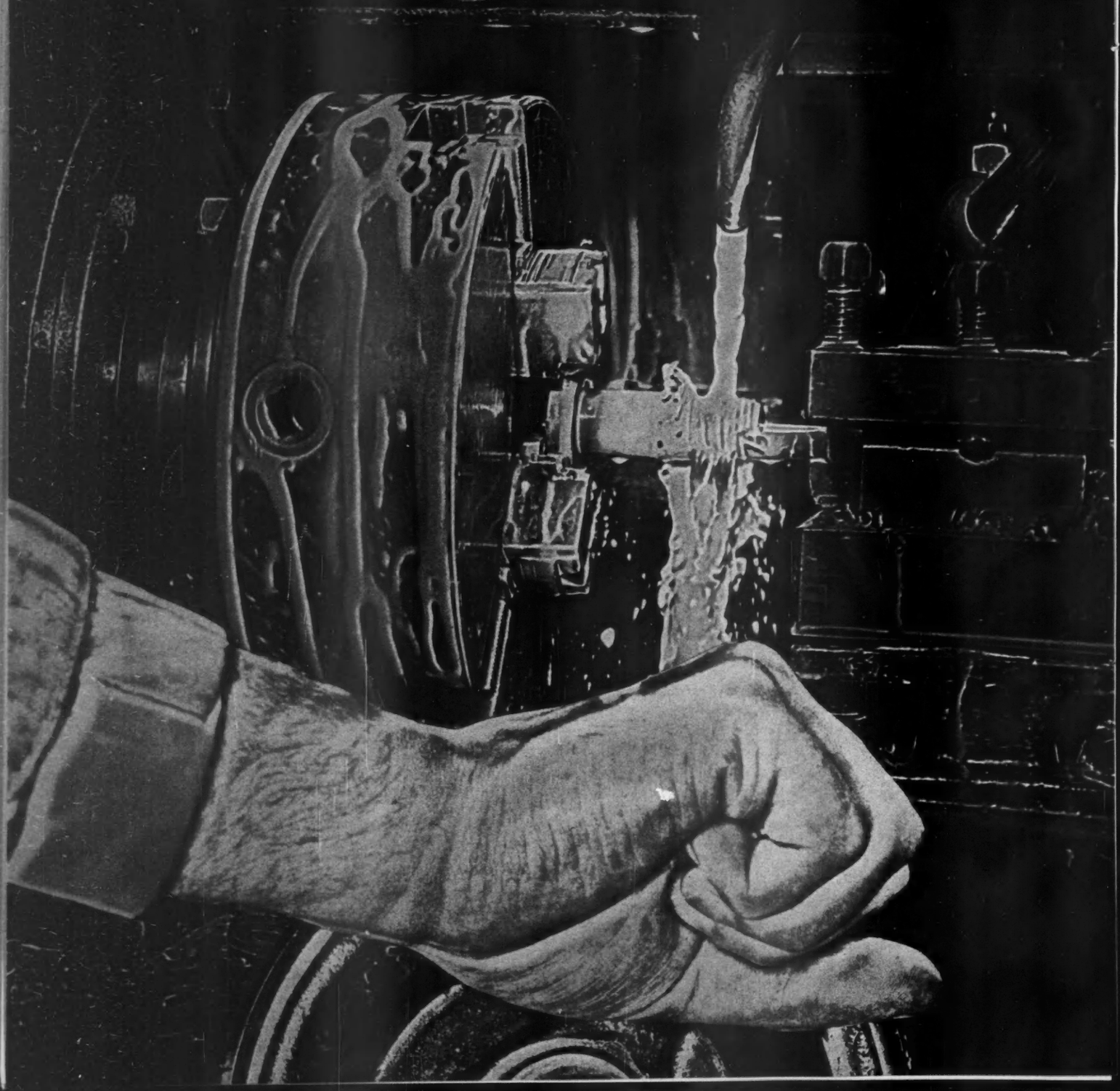
ENGINEERING
17 June 1960 25

Greater safety for hands



With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant. The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

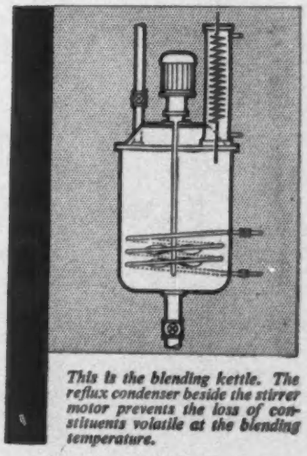
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

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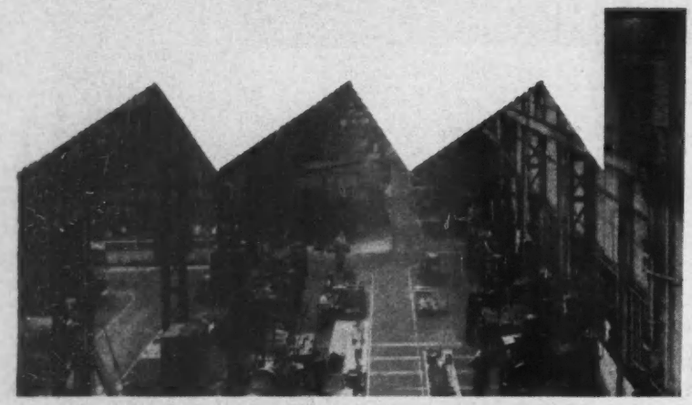
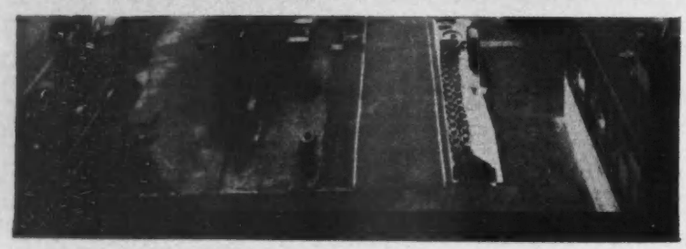
THERE'S PLANT CAPACITY AT CARRON





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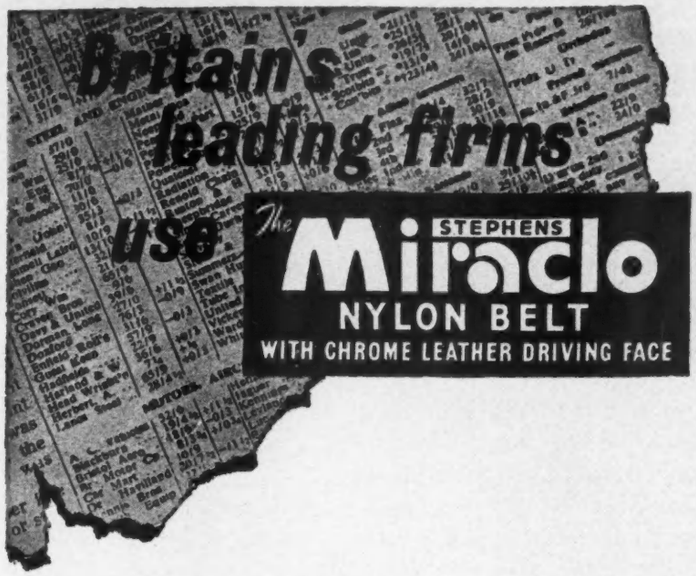

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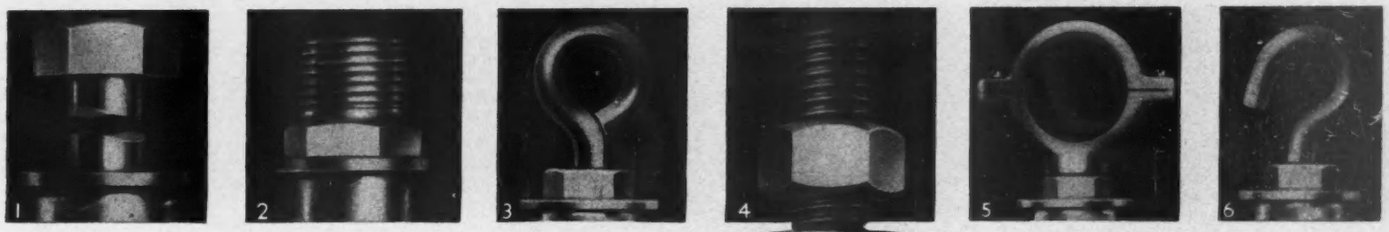

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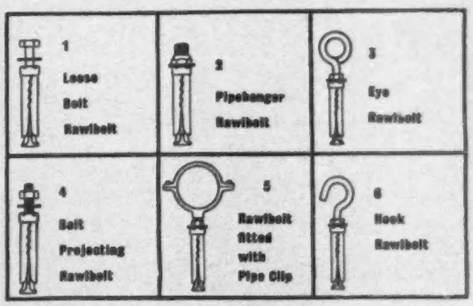

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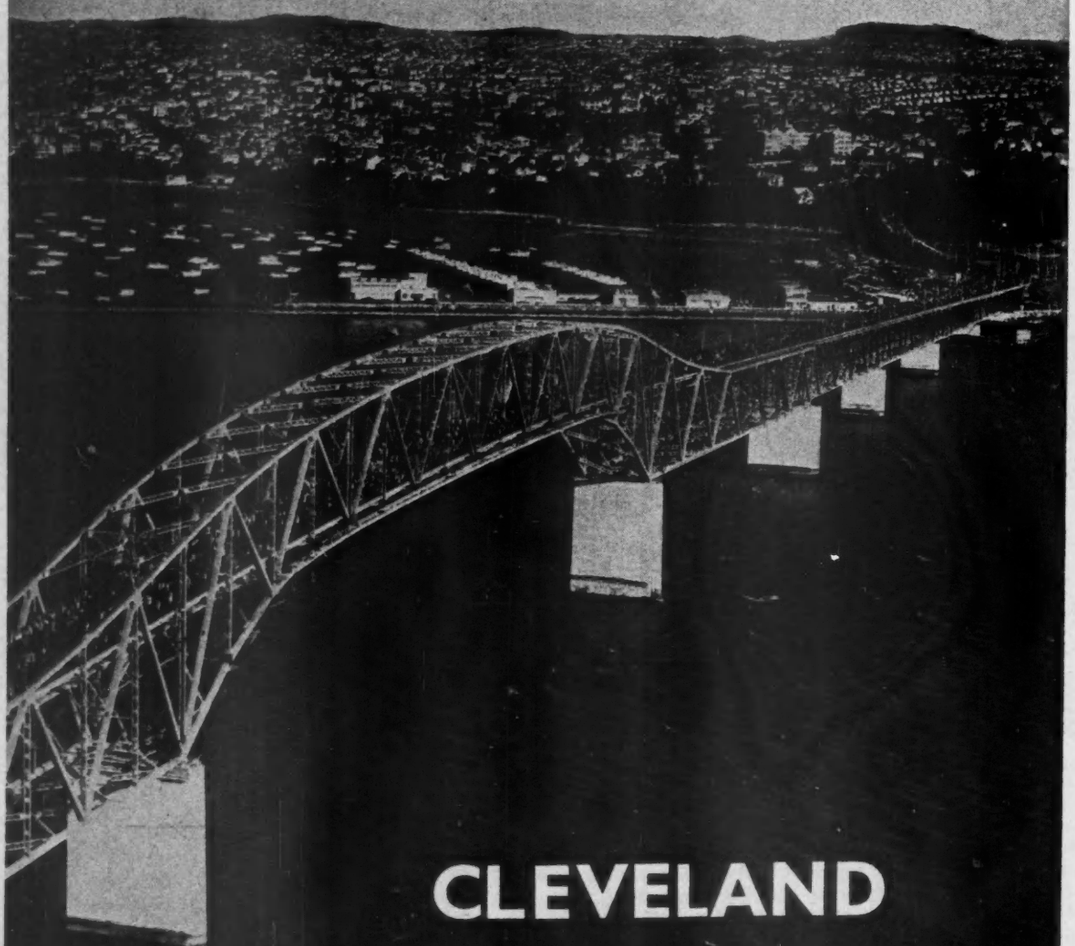

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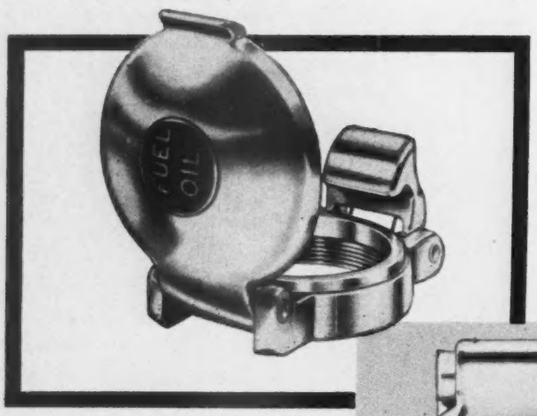

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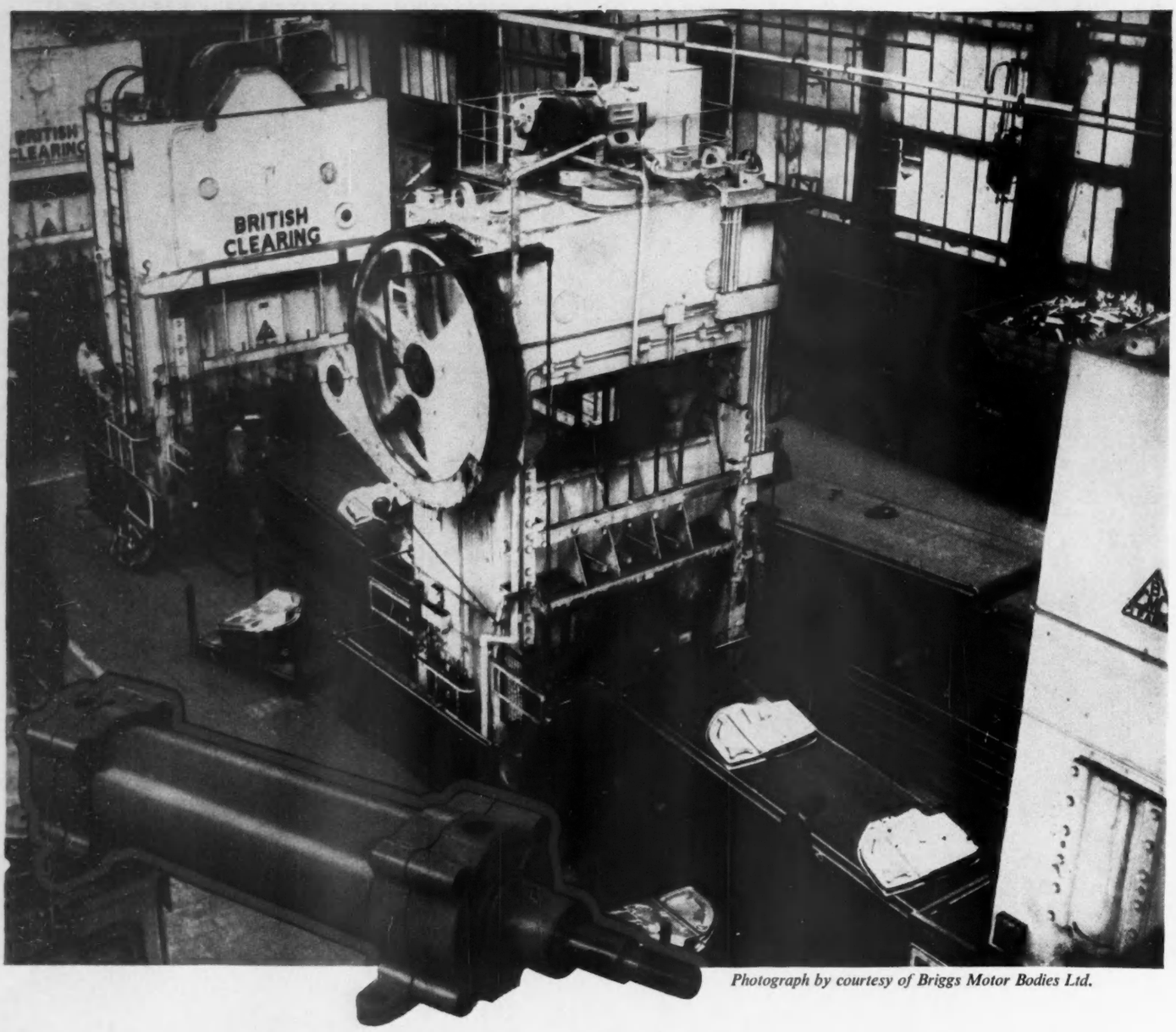

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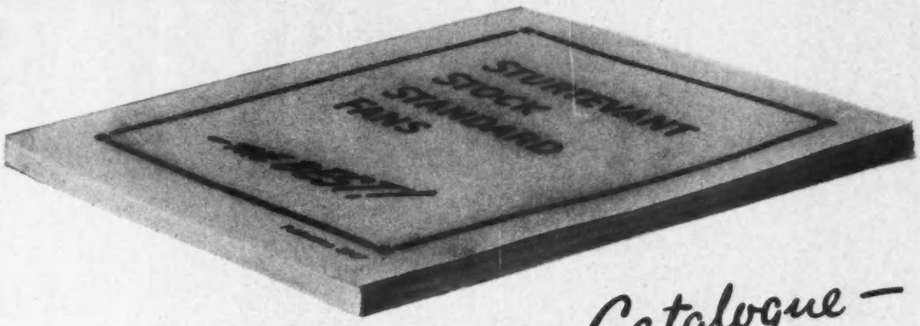

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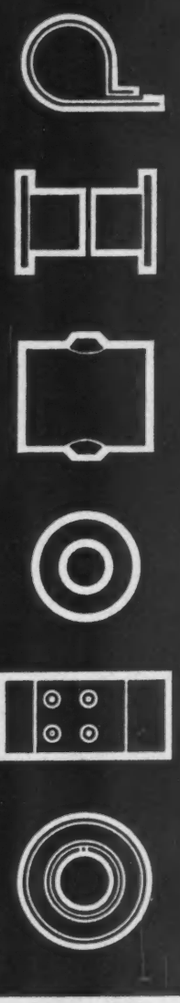

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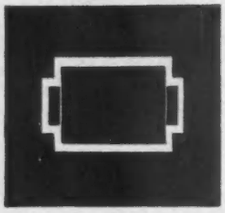

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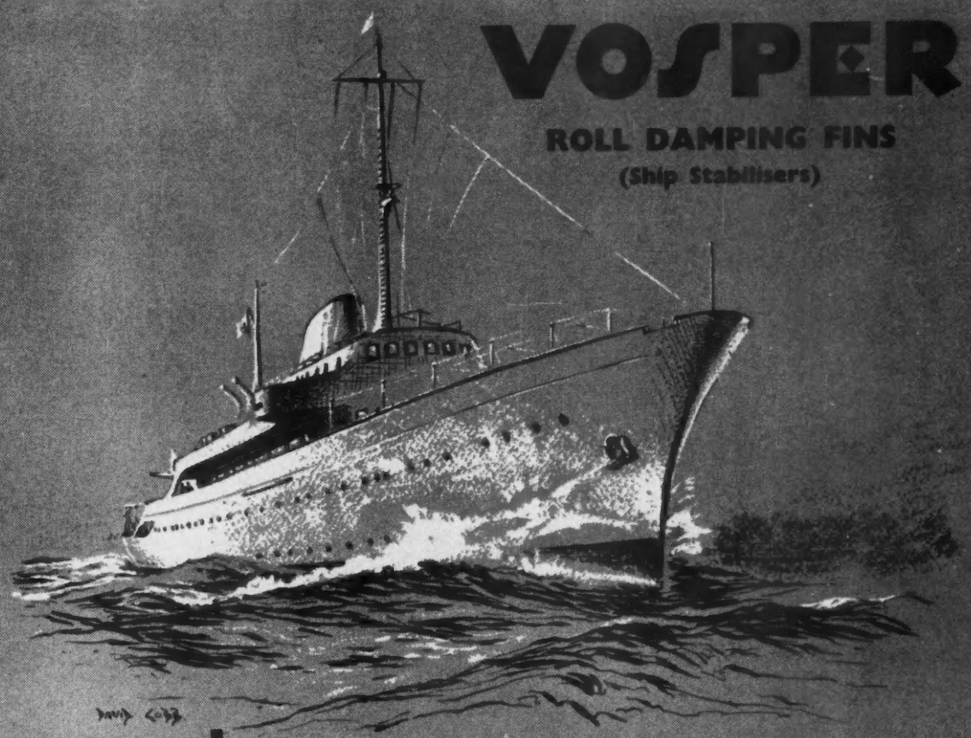

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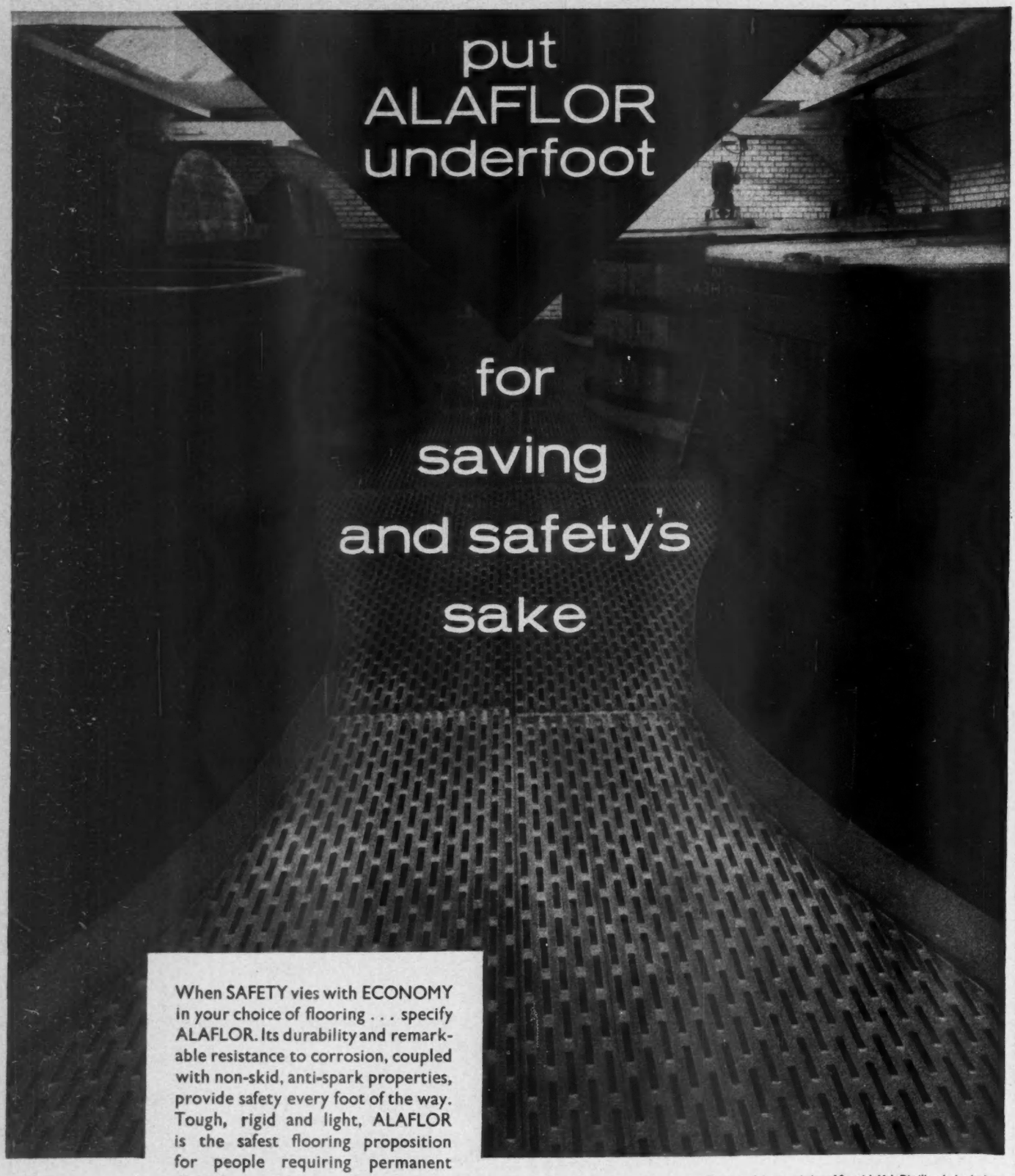

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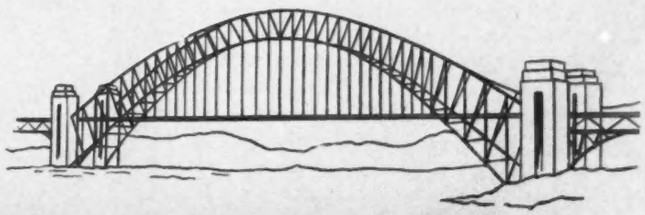

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coal begins the

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Obviously the shrewd men who control such a thriving concern have a flair for making long-term decisions that are both wise and profitable.

Raleigh use coal because all their experience has proved that coal gives them all the steam for both power and heat they need at the lowest possible cost. Raleigh are *expanding* on coal because they know that our coalfields contain all the coal that industry can use for many scores of years to come.

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When it is your turn to cast a vote on fuel, remember Raleigh. Coal is the power that starts their wheels spinning so profitably. You can make *sure* that the wheels of your industry do the same for you when you stake your future power on the most reliable of all fuels—coal.

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COAL

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Policy into practice at Raleigh Industries

Mr. L. L. Roberts,

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"Coal is the fuel chosen for the whole of Raleigh's power-raising plant, including our newest installation which comprises four horizontal economic boilers. These operate on ¼" washed smalls, and have a combined total rating of 74,400 lbs. of steam output per hour from and at 212°F.

An overall average efficiency of 72-75% can be easily maintained, although under test conditions we have recorded efficiencies of 80%.

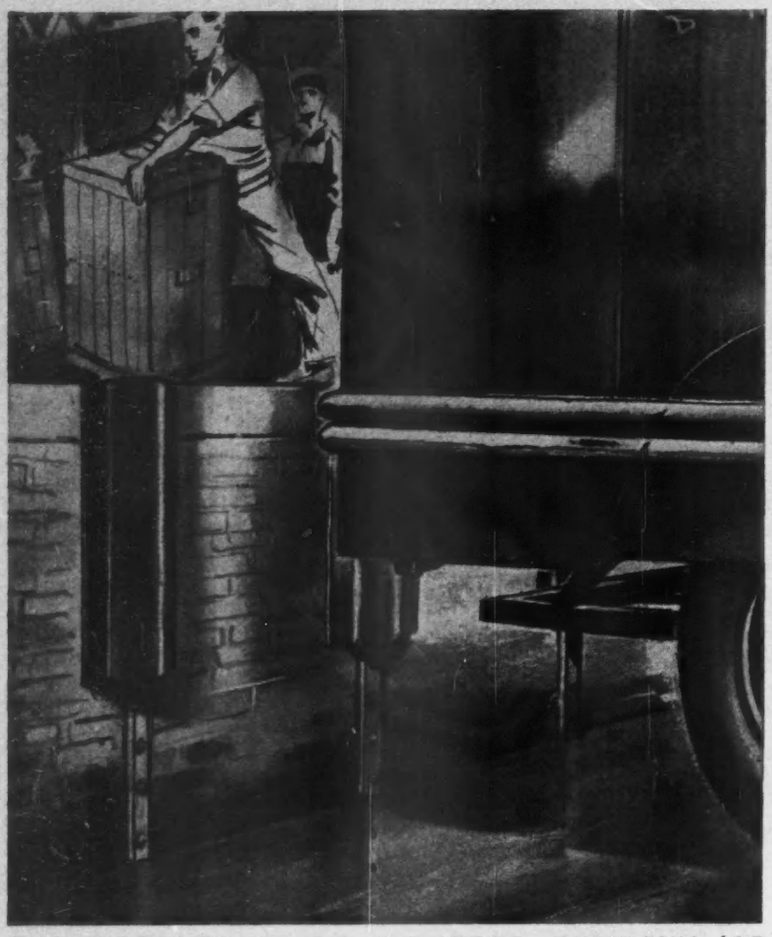
All our coal handling plant is fully mechanised and apart from periodical trimming of the receiving bunkers, the fuel doesn't have to be touched at all by our boilermen anywhere from the delivery bays to the firebeds. After burning, the ash residue is automatically conveyed to overhead storage bunkers outside the boilerhouses, from where it is easily discharged into lorries for disposal.

Our emergency stocks of coal are relatively small. We prefer to operate on a direct supply basis from colliery to boilerhouse for more or less immediate use. This would not suit every firm, but in our special circumstances I am perfectly satisfied that deliveries are reliable enough to make this system dependable, and the possibility of an emergency arising out of failure of supply is very remote. We have operated this way for three years now without any trouble at all and will continue to do so in the future.

Raleigh's decision to use coal is based on economics. We want maximum reliability at the lowest possible cost—and I'm happy to say that with coal that's exactly what we get."

And here are some key facts and figures about the No. 1 Boiler House (Orston Drive)

Boilers: ..... 4 Horizontal Economic boilers
Total capacity: ..... 74,400 lbs. of steam per hour
Method of firing: ..... Chain grate stokers
Steam pressure: ..... 80 lbs. p.s.i.
Steam temperature: ..... 324°F.
Annual fuel consumption (*all boilerhouses*): ..... 22,300 tons of coal



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ENGINEERING Impact

of Expansion Reaching the Plateau

THE Federation of British Industries' eighth inquiry into trends in industry suggests that the rapid expansion in output of last year and this will level off towards the end of the year.

As has been predicted the limiting factors are the shortage of skilled labour and of spare production capacity. A number of firms also expect to be prevented from raising their output because of the supply position in components and material.

For the engineering industries this means even greater attention to increased productivity, labour saving steps should meet with less resistance, the electronics companies will be increasingly in demand.

On the face of it this is a situation in which overtime might be expected to be on the increase, especially with 47 per cent of firms reporting unit costs up on four months ago. Instead 56 per cent report that average weekly hours are the same and 21 per cent are actually down. Only 22 per cent report that the average per worker has increased. It may be that this 22 per cent employs a higher proportion of the total working population.

While 66 per cent of the 714 representative companies say that their average selling prices are unchanged and 22 per cent report them to have risen, there are 38 per cent reporting that average profit margins have declined; exactly half the firms said they were no different.

Under these conditions, with two-thirds of the companies as optimistic as in February and a quarter even more so, the capital equipment makers should find themselves with lengthening order books. In the much smaller group of firms responsible for capital goods just over half had a higher rate of new orders coming in.

The next four monthly report may well show this trend developing.

Stockpiling—Indicator and Brake

Whether or not the Chancellor of the Exchequer will this autumn be compelled to increase interest rates and again tighten up on hire purchase is a key question exercising the minds of production engineers, managing directors and almost everybody else.

Much of the answer is dependent on what industry is doing about stocking up with materials. If the sharply rising import bill slows down because companies have what they feel is a safe level of supplies behind them then Mr. Amory —or his successor—will be under that much less pressure in the autumn.

If the increased volume of imported materials works an outgoing rise in manufactured exports then a balance between exports and imports will be nearer.

It is unfortunate that the FBI's inquiry into industrial trends throws little light on manufacturers' intentions about stocks. Under the heading "stocks of raw materials" it lumps experience of the past four months with expected changes. 37 per cent of the representative companies said that their present stock position was up on that of four months ago; 45 per cent were the same.

A useful addition to the valuable information provided by the FBI enquiry would be what manufacturers expected their future stock levels and material intakes to be.

Reconciling Diversity with Automation

The need for diversity, as well as low production costs, presents the discriminating Western world with serious engineering problems.

This requirement will be one of many that in the next ten or twenty years may transform the production process. "New Directions in Metalworking Practice" will be examined in a group of specially commissioned articles, beginning on page 825. The first, by Mr. F. Griffiths, chief production development organiser of the British Motor Corporation, forsees a revolution in manufacturing techniques.

Speaking recently at the Institution of Mechanical Engineers, another automobile engineer, Mr. V. G. Raviolo of the Ford Motor Company, Dearborn, Michigan, declared that motor-car manufacturers must learn to produce interchangeable components in great volume and to make a variety of vehicles from these components. This had been done to some degree, but more ingenuity would be required in the future. Internal body structures common to several car lines had been used by the Ford company and their competitors, and also in England. But it was necessary to go much further with the mechanical components than had been attempted so far.

Alternative Plant

The optimum range would be created by providing a series of shells, into which alternative power plants could be fitted. The concentration of substantially all the mechanical parts into power packages would permit a high degree of interchangeability.

Such power packages would not be affected as readily by styling change as conventional chassis were, with the result that a high degree of automation could be justified.

This development is also desirable in other industries. By designing components to be common to a range of products, longer production runs and cheaper manufacture can be achieved without sacrificing the variety which is so much a part of Western society. Britain, with its smaller population, and consequently smaller scope for mass production, has special reason to favour unit construction. Even machine tools might be susceptible to this treatment, several types of tool being based on a single set of building bricks, with the number of parts unique to each type kept to a minimum.

By the rationalising of stores procedure, the same component may be found to serve a greater variety of purposes, once more leading to longer production runs and cheaper manufacture. We are likely to see a substantial reorganisation of production and design along these lines.

of Australasian Oil Prospects

Australia needs oil. And it needs it badly, to the tune of over 10 million tons in 1960.

Imports of crude oil in 1959 amounted to 9,800,000 tons and over a million tons of already refined products were brought in. What is more, this 7 per cent increase in consumption over the previous year is expected to continue. This is hardly surprising—for oil, in all but the coalminers' eyes, is the lifeblood of modern industry.

It is interesting to read, therefore, of the continuing successes of the sixty-nine companies who are at present searching for oil in Australia. Drawback to the searches is the lack of information on soil and rock formations which enables the drilling companies to know what they can expect to find. Among the people are trying to change this are the Petroleum Institute of France. They will work with the Bureau of Mineral Resources who have just published a survey of what's happening . . . first aim of the French institute is a survey of sedimentary basins in Australia.

What does the discovery of oil in Australia mean to this part of the Commonwealth? Basically, freedom from imports which currently come from Indonesia, the Middle East and America. Australia has the refineries, but not the crude. The country is apparently steering clear of ties with countries under Soviet influence. Mr. I. Fedovov of the USSR Export Commission succeeded in selling only a small amount of lubricating oil during a seven week visit to Australia aimed, no doubt, at capturing a part of the Australian imports.

No drillings have yet yielded useful oil, except one at Rough Range in Western Australia which has turned up both crude and gas. The report of the Bureau, however, confirms the opinion of geologists that petroleum is likely to occur in useful quantities both in Papua, New Guinea and in Australia.

That Australia has confidence in her ability to maintain a politically stable source of crude or else turn up a home supply is confirmed by the action of companies like Shell Chemicals and ICI. Their branches in Australia have joined hands to establish a relatively new petrochemical industry by investing £A10 million in a plant for manufacture of polyethylene.

A major oil strike at home would be good news.

New Resources and Energy Transmission

Fossil fuel, vegetable fuel and hydro-electricity are today our most important energy resources, in that order. But 100 years from now the order may well be nuclear energy, fossil fuel, and solar energy.

This educated guess was made at the World Power Conference in Madrid, and is primarily based on the observation that the earth receives more radiant energy from the sun in one year than is contained in all the world's known reserves of coal, oil, natural gas, uranium and thorium. It is an energy source that cannot be left ignored for long.

One of our great headaches today is energy transmission. Present trends of population growth, urbanisation, and the movement of populations into energy poor areas all tend to worsen the situation. Richard L. Hearn, retired chairman of the Ontario Hydro-electric Commission, would give top priority to solving the problem of transporting large quantities of energy over long distances cheaply. But perhaps our difficulties will tend to solve themselves with time.

The interesting difference between the energy sources of today and tomorrow is that whereas now the energy is found in distinct packets on the earth's surface and must be transported over long distances to the consumer, the energy of the future can be generated at the point of consumption.

Nuclear energy is virtually independent from the uranium and thorium mines, and the cost of transporting fuel is almost negligible compared with the overall cost. And the sun shines everywhere. Even in foggy northern climates, such as endured in Britain, solar energy can be exploited usefully.

and Euratom in the Doldrums

Euratom has been in the news lately as the part of six-nation Europe that Britain might join. What sort of shape is Euratom in at this time? The answer, according to the recently published Third General Report on its activities, is not too reassuring. The main problem is that Euratom has been hit by the change in the energy position over the past three years. As a result enthusiasm for big capital spending on nuclear projects has waned.

The introduction to the report expresses the need to intensify the efforts of the members and vigorously denounces their lack of "active awareness of the Community." The report continues "How can it be thought that Europe can maintain in the world the place to which it has a right by virtue of its contribution to civilisation and the quality of its men, if each country acts in isolation and falls back on its own resources, and if the initiatives taken by the Institutions of the Communities run up against the reticence, if not the actual opposition of the member countries which should be giving them their full support?" Add to that the fact that the record of achievements of the Commission is one of agreements in principle and of "work at the preliminary stage." A number of interesting projects are in hand, such as the study of the effects of radiation on animals in Holland, and the research in uranium substances at Karlsruhe.

The Commission forecasts that in 20 years' time the production of nuclear electricity will exceed total production today, accounting for 30 per cent of the total generated output. The Commission has little to say about the failure of members to submit schemes last year for power stations to be financed under the Euratom-United States agreement.

One item in particular which underlines the less than urgent view that the Euratom countries are taking of their responsibilities and opportunities is that the money spent on the 1958 and 1959 research budgets is only a fraction of the initial estimates. Should Britain join Euratom? By all means if it is going to help bring the Six and Seven together. But let there be no doubt about who is doing a favour to whom.

Still Hotter Horizons for Thermocouples

Metallic thermocouples are known which look useful up to 2,800° C. But insulator and sheath materials can behave oddly. Meanwhile, designs of low cost sheathings for continuous pyrometry are improving.

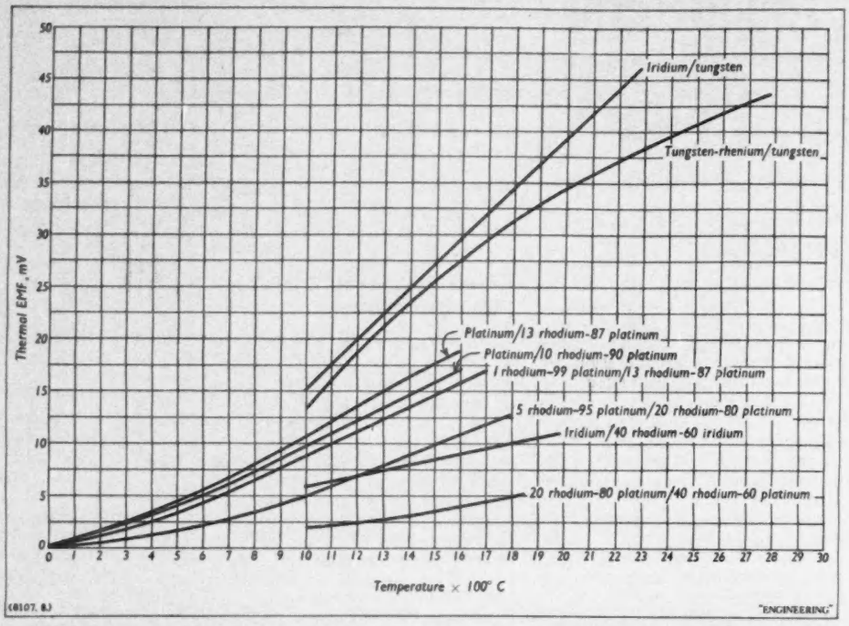
As temperatures go higher, so must our standards of accuracy in measurement. Once the thermocouple has to be cast aside in favour of the radiation or optical pyrometer the accuracy takes a turn for the worse. Take a good look, therefore, at the range of metal thermocouples which are now being made for use at temperatures way over 2,000° C. Their characteristics and temperature usefulness are shown in the illustration.

Existence of such combinations does not solve the even more acute problems of choice of insulator and sheath, granted that the thermocouples themselves are reproducible in performance. These allied problems are considered on the opposite page.

Advantages of metallic thermocouples as accurate, robust and flexible devices for measurement of elevated temperatures are well known. Precious metal couples are employed in industrial and scientific applications where accuracy and stability are required and their use becomes mandatory where the temperatures to be measured are above the effective range of the base metal couples and where considerations of chemical attack or oxidation arise.

When length of life and maintenance are taken into consideration, together with the useful scrap value of precious metal thermocouples, the cost of using precious metal thermoelements does not compare unfavourably with use of base metals—a fact not always appreciated by those more familiar with the latter. There is necessarily some degree of overlap in the useful range of the individual combinations and advice is always available on selection of the most suitable couple from a firm who specialise in them, such as Engelhard Industries, who have supplied the following information.

Use of platinum/platinum-rhodium thermocouples has been long established as the most reliable method for continuous measurement of elevated temperatures in the range up to 1600° C. Development work has been concentrated on the higher melting point metals of the platinum group and on the highly refractory base metals of groups V and VI of the periodic table. Feussner's introduction of the iridium/40iridium-60rhodium thermocouple in 1933 extended the range of thermoelectric pyrometry to 2,000° C. Subsequent work has shown that the iridium/40rhodium-60iridium couple provides similar thermoelectric characteristics to the original Feussner couple but with greater stability of calibration, and this couple still finds wide application.



Voltages up to 2,800 °C await exploitation.

Amongst the refractory base metals investigated, work has been discontinued on tantalum and niobium owing to their highly reactive nature at the temperatures of operation. Tungsten/molybdenum has found limited application but suffers from the following disadvantages: thermoelectric output is low and undergoes an inversion of polarity at approximately 1,250° C; characteristics of the couple are sensitive to minor variations in methods of fabrication and reproducibility from batch to batch is correspondingly poor; and both thermoelements are readily oxidisable necessitating provision of a protective atmosphere during operation.

Platinum/10rhodium-90platinum and platinum/13rhodium-87platinum.—These are the most widely used of noble metals thermocouples, and are recommended for continuous use up to 1,500° C and intermittent use up to 1,600° C. Longer life at the upper limit is obtained if a fibrous element made by Engelhard is employed for the platinum member. Suitable for use under oxidising or neutral conditions or in vacuum. Choice between these two couples is generally dictated by available instrumentation.

1rhodium-99platinum/13rhodium-87platinum.—This couple was developed for use in long term applications such as creep testing, as drift is low. Maximum continuous temperature is 1,600° C and it may be used intermittently up to 1,700° C.

5rhodium-95platinum/20rhodium-80platinum.—Use of a negative member of high rhodium content provides high mechanical strength and extends the operating range to 1,700° C for continuous use and 1,800° C for intermittent use, whilst having low drift from rhodium migration.

20rhodium-80platinum/40rhodium-60platinum.—This couple may be used continuously at temperatures up to 1,800° C and intermittently at 1,850° C. Output is very low and the more recently developed iridium couples mentioned below are more popular.

Iridium/40rhodium-60iridium.—This may be used at temperatures continuously up to 2,000° C and intermittently up to 2,100° C in oxidising and reducing atmospheres or vacuum. The couple possesses good stability of calibration. Recrystallised alumina sheaths and insulators may be used up to 1,850° C as with the other platinum thermocouples, but above this magnesia or thoria may be used, although magnesia should not be employed in vacuum.

Iridium/tungsten.—This couple allows the top temperature to be raised even further to 2,200° C and 2,300° C for continuous and intermittent use respectively, in vacuum or inert atmospheres, and for short periods in reducing conditions.

Tungsten-rhenium/tungsten.—This resulted from research work at the Rugby research laboratories of the AEI Lamp and Lighting Company. It is suitable for measurement of temperatures of 2,500° C continuously, and intermittently up to 2,800° C, in reducing, or inert atmospheres or vacuum.

Non-metallic Couples Being Developed

The research department of Morgan Crucible Company has been carrying out work on use of electrically conducting non-metallic materials for thermocouples. These have interesting properties but have not yet reached the stage of development where they are ready for works use. Meantime, a limited range can be produced for laboratory experimental use.

Silicon carbide/graphite.—This gives a very high emf and can be used to high temperatures. It will give quite long service at temperatures up to about 1,500° C and can be used for short periods up to about 1,900° C. Life depends very much on conditions, and if the atmosphere is oxidising the thermocouple usually fails ultimately due to oxidation of the central graphite rod. Output is approximately 0·2 mV per ° C and development work has reached the stage where thermocouples of quite good stability—usually within 1 per cent—can be provided, but Morgan's are still having difficulty in obtaining reproducible results from one thermocouple to the next. Considerable variations are found in output when comparing two similar thermocouples and at present this difficulty cannot be overcome, so that it is still necessary to calibrate each thermocouple separately. The characteristic is quite straight above 500° C and it is usually only necessary to calibrate at one or two temperatures in the normal working range.

The standard silicon carbide/graphite thermocouple consists of a silicon carbide outer tube, 10 mm o.d. and 12 in long. A graphite rod, insulated from the silicon carbide, passes down the inside of the tube and is sealed to it at the hot junction end. An alumina coating can be provided to minimise oxidation and the contacts at the cold ends of the thermocouple are metallised. Longer thermocouples can be produced.

There is some difficulty in obtaining satisfactory compensating leads, due to the high output of the thermocouple. It does not seem likely that a simple compensating lead will be obtainable, but a double compensating lead employing a series cold junction thermocouple shows some promise.

All silicon carbide.—Due to the semiconducting nature of silicon carbide it is possible to make

p-n junctions between one grade and another. These can be produced to give a wide range of output, up to about 0·1 mV per ° C. Concentric thermocouples have been produced up to 30 in long and 22 mm o.d. and experiments are being made with small sizes approximately $\frac{1}{16}$ in o.d. and 6 in long. These are also capable of being used continuously up to about 1,500° C or for short periods up to about 1,900° C.

Choose the Best Insulators and Sheaths

There is a great difference between selecting insulators and sheathing materials for accurate measurement at temperatures above 1,800° C, and for low cost general use around the 1,000° C mark. The latter is theoretically straightforward and means designing for withstanding mechanical and thermal abuse and contamination. But for the high temperatures, industry is only beginning to understand the theory, let alone the practice.

For instance—insulators. Above about 1,500° C most oxides and nitrides begin to conduct electricity, and also start to generate thermoelectric voltages in contact with metals and other ceramics. Thus an apparently effective system of thermocouple, insulation and sheath may be generating a quite misleading overall voltage. The calibration curves supplied by Engelhard were obtained at the highest temperatures without insulators and sheaths and are therefore only a promising beginning to application of couples like tungsten-rhenium/tungsten.

Oxides are the mainstays of high temperature sheathing: alumina up to 1,850° C, magnesia or thoria beyond this but not in vacuum because of the high vapour pressure. Beryllia sheaths and insulators are used in the USA above 1,850° C but are not made in this country. Short circuiting of insulation can be largely avoided by designing a single wire loop similar to that shown below for the integral sheath thermocouples, but this is not a very strong arrangement when the outer metal sheath is removed for high temperatures.

A good survey of what shielding material to use in non-ferrous foundry practice has been made by D. W. Brown in *British Foundryman*, March, 1958. Morgan Crucible have now further developed their cermet tubes and have designed two robust shields for foundry use which are commented on below. These hold great hope for continuous immersion pyrometry.

Sheaths for Continuous Immersion

Difficulties with pyrometer tubes for continuous immersion in molten metal are well known and have often resulted in such pyrometry being abandoned in spite of its technical advantages. Existing tubes all have important shortcomings for this application.

Modern heat resistant alloys can withstand temperatures up to 1,200° C or even 1,400° C but are severely attacked or dissolved by many molten alloys and slags. They often give some service if protected by a ceramic coating but such coatings must be cleaned off and replaced at frequent intervals.

Ceramic tubes are generally too weak and brittle to give long service under industrial conditions, and are moreover liable to thermal shock cracking. If they are made with thick walls to provide strength they have a poor response to temperature change and are even more subject to thermal shock. Silicon carbide is usually the best choice but Salamander (clay-graphite) has a better resistance to thermal shock.

Fused silica tubes are widely used for dip immersion in steel but will not withstand long periods of immersion. A pure recrystallised alumina tube with a porous alumina coating to reduce thermal shock is used successfully for period immersion in steel but it needs careful handling.

Electrographite tubes are excellent for dip immersion in non-ferrous metals and cast iron but suffer from oxidation if they are immersed continuously.

Cermet tubes can be used for continuous immersion as well as for dip readings. However, they are attacked by some alloys, especially aluminium alloys, and also by some fluxes. Before introducing the two ceramic tubes which Morgan Crucible think are winners, let's look further at these cermet tubes.

Cermet sheaths.—Called Metamic by their makers, Morgan Crucible, these have a unique combination of useful properties. They are refractory and have cold strength about equal to cast iron in conjunction with excellent thermal shock resistance. They therefore combine many of the advantages of ceramic sheaths with those of fused silica and of metal tubes.

The first grade, 519, is very refractory and can be used at temperatures up to 1,900° C for short service. It contains metallic molybdenum and is therefore liable to oxidation if used continuously in air. This is the standard grade offered for quick immersion work in steel and in high temperature alloys generally. It has proved particularly successful under vacuum conditions where the question of oxidation does not arise.

In vacuum furnaces melting steel and similar high temperature alloys a life of up to 40 dips has been obtained and it is quite practicable to allow the tube to remain in the metal for 2 to 3 minutes to obtain more continuous readings. In air the tube is only recommended for dip readings but lives up to 40 dips have been obtained in high temperature iron and up to 12 dips in steel.

Metamic 519 tubes are not generally used in

Reduced-end Salamander sheath with constant immersion-depth supporting mechanism.

open hearth furnaces and similar steel melting furnaces carrying a heavy slag, since this tends to wet the tube and build up on it. After 4 or 5 dips it is then necessary to remove the slag layer, otherwise reading becomes too slow and there is a danger of the tube being damaged mechanically by the weight of slag. The slag can be removed by allowing the tube to cool until it has reached a black heat and then immediately quenching it in water. This will crack the slag which can then be removed quite readily.

The second grade, Metamic 528, contains chromium and is always provided with an inner lining of pure alumina to prevent contamination of platinum thermocouples. It is usable up to about 1,650° C.

General properties of Metamic 528 are similar to those of 519, but it is more suitable for use under oxidising conditions and in special cases where the presence of molybdenum would be undesirable. In copper alloys up to 16 dips each of 5 minutes duration have been obtained and Metamic 528 is also used in vacuum furnaces melting steel and in small arc furnaces melting special alloys in air.

Metamic 612, the third grade, has been developed mainly for continuous immersion pyrometry at temperatures up to 1,450° C. It will give a very long life in brass, some months, and is also used satisfactorily in phosphor bronze and similar copper alloys. It is not suitable for aluminium. The larger 612 tubes are not immune from thermal shock and although elaborate preheating is not needed they should be warmed up before immersion in molten metal.

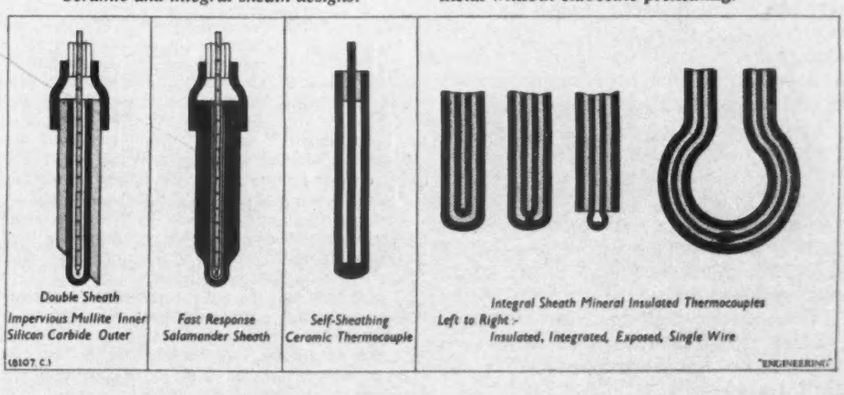
Composite ceramic tubes.—Mullite-silicon carbide tubes, as illustrated, have been developed specifically for continuous immersion pyrometry. The stout silicon carbide outer tube, open at the end, gives good mechanical strength and resistance to attack by slags and fluxes. The inner impervious mullite tube provides good protection for the thermocouple and being thin, gives a rapid response. Such tubes are widely used for immersion in aluminium alloys and also in brass and bronze. Unfortunately, they are not very resistant to thermal shock and must be preheated to about 350° C before immersion in the melt. If they are used carefully they are capable of giving long service. These composite tubes are not suitable for use in ferrous metals, which attack silicon carbide.

Quick response Salamander.—This reduced end Salamander tube is intended to overcome the difficulties detailed above. In tests so far it has given very promising results in aluminium alloys, copper alloys and cast iron.

Salamader has excellent resistance to thermal shock, good thermal conductivity, good resistance to slags and reasonable strength. It is supplied ready glazed to resist oxidation. The design, shown below, is deliberately short and stubby to give good mechanical strength and the tube is well able to withstand normal handling. The thick wall at slag level ensures long life before the tube erodes thin, while the thin reduced end surrounding the actual thermocouple junction gives rapid response to temperature changes.

Use of a loose impervious porcelain inner tube is essential when platinum thermocouples are used and such inner tube is also generally recommended when base metal thermocouples are employed. The standard inner tube is impervious aluminous porcelain but for temperatures above 1,350° C a similar impervious mullite tube is recommended. The tubes are resistant to thermal shock and can be plunged into molten metal without elaborate preheating.

Ceramic and integral sheath designs.



Plain Words

By Capricorn

WHAT do people think of when you say someone is an engineer? What kind of image does the word evoke today?

I was startled to read the answer given to that question by Mr. Mike Williams-Thompson. He is a public relations man, and as a professional seer of people as others see them, his opinion is worth having. He has worked with engineers in the armed services, the civil service and industry. In his latest book, *On the Record*, this is what he says:—

> In Britain, the engineering profession is regarded as a dirty one. In America, in Russia, and in Germany no one is ashamed to call himself an engineer; in fact in most European colleges it is an honour to get a technical degree permitting one to put the word "engineer" in front of one's name . . . Things here are different; the word "engineer" is not considered respectable, and the instinctive picture is one of someone who looks dirty and who holds an oily, greasy rag in his hand. Until we alter this social outlook, Britain will not have enough engineers for her needs, and parents will not tend to put their children into the profession.

There's a fine state of affairs for you! Never in the history of man have there been so many washing powders, soaps, shampoos, detergents, barrier creams—yet never have men been so afraid of getting their hands dirty. More and more future engineers want to avoid the disagreeable necessity of going through the shops. Among the great army of skilled, semi-skilled and unskilled workers there is a decided preference for the white-coated jobs. We all aspire to a clinical, air-conditioned environment, where we can masquerade as high priests of the latest technological religion.

I wonder what colourful words would have been used to describe this antiseptic snobbery by the great engineers of the 19th Century—and many of the 20th too—who never forgot that engineering is a practical art. No sensible man enjoys getting dirty, but there is no reason to feel inferior if in your career you have worked on a dirty job.

Many of the traditionally dirty jobs are in fact disappearing. On the railways, for example, those industrial slums the locomotive running sheds are being replaced by modern service depots for electric and diesel locomotives. Even in heavy engineering, the modern shops are clean, tidy and bright.

Meanwhile nothing is being done to alter the public image of an engineer. It would be no good engineers adopting a chip-on-the-shoulder, I'm-as-good-as-you attitude, but at the present time they are doing practically nothing to correct the false impression. It is, indeed, extremely difficult to say exactly what engineers do.

That is the challenge. Mr. Williams-Thompson has put into words what many engineers had feared is true but few have had the heart to say.

Letters to the Editor

Speaking Our Minds

SIR, "That efficient central body to assist the inventor to work up his ideas, whereby the State or industry can take over," which Mr. A. W. Capps asks for in his recent letter to you (ENGNG., 10 June '60, p. 776) can surely be nothing more or less than a larger and better—or smaller and more limited—National Research Development Corporation, with all the possible defects of such an organisation which he has listed.

No. The solution of the acute current problem lies in other and wider directions; and our future existence as an industrial nation depends on this solution. This existence depends, not on trade and commerce, but on engineering and industrial enterprise and efficiency. It is difficult to see how this can be achieved when most industry is under the control of men interested in the profit rather than the product; and when there is little or no incentive for men of ambition on the creative side.

The current—and increasing—dependence on manufacturing foreign designs under licence, resulting from this outlook, is rapidly eroding our own creative abilities. Another reflection of the same factor is the neglect both by educational, industrial, and Government establishments, of the importance of "Design": that process of transfer from thought to material which gives to an idea the possibility of material existence, and determines the quality—in all senses—of the product.

The calling of an inventor is no doubt a high one, particularly if he can define his invention with sufficient clarity to enable manufacture to proceed without hesitation or doubt. Too many inventors, however, still tend to relegate the real design work to a lower level of thought. Too many ideas originated in this country are not properly developed (designed), are neglected by our own industry, are taken up by other countries, and then manufactured here under limited licence.

This process has been going on for fifty years or more. Its correction needs a nation-wide realisation that we are not earning our living as a nation at present, that the foreign market is the dominating factor, and that the product is the thing of real importance. If proper attention is paid to all aspects of this—including selling it—the profit, as a kind of by-product, is almost automatic.

One can only hope that it is not too late for us to put our national, educational, and industrial structure into such a shape that we can expect to survive.

Yours truly,
HUGH CLAUSEN.

17 Harman Drive,
London, NW2.
11 June, 1960.

Legal Aid for Inventors

SIR, I have read with much interest the Human Element article which has appeared under the title "Cold Shoulder for the Inventor" (ENGNG., 27 May '60, p. 717).

I am afraid I do not quite understand the paragraph dealing with the references to Legal Aid, and in particular the one which reads "On this point, since almost £1,500,000 was spent on the Legal Aid Fund last year for the purpose of unproductive legislation, it is worth saying that pump priming with a fifth of that sum might well lead to highly productive results."

I presume that the author meant unproductive litigation, but surely any scheme which is designed to see that those with a case secure justice cannot be called unproductive. In any event, a large number of the cases concerned are matrimonial causes to which perhaps your author would not wish to ascribe the particular adjective he has chosen.

Yours sincerely,
HERBERT LLOYD,
Under-Secretary.

The Law Society,
Chancery Lane, London, WC2.
2 June, 1960.

Surface Measurement

SIR, There have appeared in recent issues of your journal two articles dealing with surface measurement: one, by Mr. M. P. Rubert, under the title "Confusion in Measuring Surface Roughness" (ENGNG., 23 Oct. '59, p. 393), and the other, by Mr. R. E. Reason, under the title "Orderly Progress in Surface Measurement" (12 Feb. '60, p. 230), on which there was a letter from Mr. Rubert (25 Mar. '60, p. 408).

One can observe that the tendency is towards observing the surface roughness measurement in an ever increasing extent and to control it. This can be achieved if the surface quality can be measured and determined in terms of numerical values. The larger the field on which the surface measuring extends the more complex and variable are the surface qualities which must be determined and specified through measurement. The development has been carried out in many countries so that some numbers for the surface measurement are used, for which definitions are put down and which can be deduced from measurement with various surface instruments.

It is natural that in these countries various surface measures are preferred; these measures are caused by courses of development. While, on the Continent, a variety of different measuring standards are used to specify a surface, there is only one fixed standard recognised in Anglo-Saxon countries. This fact can perhaps be explained by the historical development, but the unbiased scientist cannot, however, understand such previously adopted limitation which must affect the industry with its drawbacks.

One can construct for one surface number many profiles which differ in character, but still have the same value. In the aforementioned articles there were given examples of such cases. It then follows, as a matter of fact, that one single number or parameter is not adequate to describe the quality of the surface. This becomes especially evident when one studies diagrams recorded for various machined surfaces. It is thus frequently recommended that a second number has to be determined and possibly the ratio of the two numbers at the same spot. This results in a more descriptive method of the surface quality.

It is recommended that besides the surface measuring number the method of machining is given. This can in some cases make the distinction possible, especially when, with similar machining methods and similar machining conditions, different surface values result. As soon, however, as the machining process or details are changed, then the distinction with one number becomes uncertain. Also, when the marks of several machining processes are superimposed, one number gives rise to false meaning. The profile record can give much clarity, but this is only taken if there is a reason. If the validity of the measuring is not in doubt but recognised, the errors of evaluation cannot be detected.

In every surface roughness standard, there are certain profiles which are unsuitable for that particular standard; for instance, it is meaningless to specify Centre Line Average (CLA) values for the surface finish of slip gauges because the values are too small and because the actual depth of certain scratch marks resulting from lapping, will not be considered. On lapped surfaces, we must distinguish between the general roughness and the depth of more or less frequently appearing scratch marks. This can only be done by measuring the sequence of maximal depth over a certain sampling length.

The CLA value is very comforting to the production engineer because of its lesser degree of scatter as compared to that of the maximal

depth, but exactly for that reason the CLA value is less descriptive and discriminating, since the scatter of the maximal depth corresponds to the actual condition of the surface on the spot of measurement. There are numerous cases in which the CLA value is inadequate; for instance, if we want to know whether a sheet is of the right surface quality for galvanisation, we must know the maximal depth. The same applies to fatigue tests. Recording diagrams is taking up much time and is needing a recorder. Therefore, routine tests are made by measuring surface numbers.

The conversion of a surface number, e.g. the CLA value, into a different one, e.g. the maximal depth, is complicated and not accurate. According to the results published by Rubert an inaccuracy of the conversion factors by ± 40 per cent may exist. For that reason this method cannot be used.

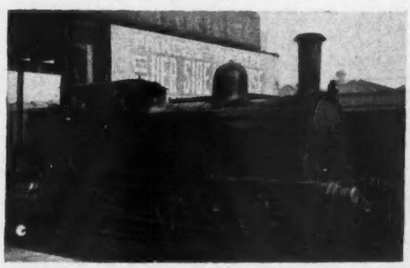
It is not intended by this to reject the CLA standard altogether. It has its applications and justifications, but there are also other cases which require different standards. This fact has been established by so much experience that it cannot be denied. Should a technical progress ignore these facts in considering the surface quality? On the Continent we have decided to make use of every standard which has been developed in that field. The problems arising from surface roughness measurement are very complex and numerous, therefore the means of assessment should also be numerous and adaptable.

Yours truly,
HANS W. SCHMIDT.

65 Andreas-Hofer-Strasse,
Mannheim-Feudenheim, Germany.
7 June, 1960.

Webb Coal Tank Engine

SIR, A fund has been launched to raise £666 to purchase for preservation the last of F. W. Webb's engines to remain at work, which is also the last of the London and North Western Railway's 0-6-2, 4 ft 3 in side tank coal engines, B.R. No. 58926. It is hoped to restore the engine to its original condition and livery and to



maintain it in working order. A photograph of the engine taken some 40 years ago is reproduced here.

Contributions, however small, to the Webb Coal Tank Engine Preservation Fund will be welcomed and should be sent to me at the undermentioned address.

Yours faithfully,
J. M. DUNN.

The Keeper's Cottage,
Brightling Park,
Robertsbridge, Sussex.
7 June, 1960.

World Reactor Firms

SIR, I have just read with interest your survey of world reactor companies, associations and activities; in particular the issue in which you deal with the Bechtel Corporation (ENGNG., 6 May '60, p. 620). Unfortunately, the statement concerning this Corporation is incomplete, and I have therefore had the following summary of our associations and activities prepared:—

Associations

Engineering-construction organisation, associated for various projects with Westinghouse, General Electric, General Atomic, Atomics International, and Combustion Engineering. Member of the Nuclear Power Group.

Activities

Engineer-constructor to GE for the 180 MW(e) Dresden reactor. Prime contractor for the 50 MW(e) Humboldt Bay reactor for Pacific Gas and Electric, and 40 MW(e) Peach Bottom gas-cooled reactor for Philadelphia Electric, and the 50 MW(e) Big Rock Point reactor for Consumers Power Company. Engineer for the Hallam, Nebraska 75 MW(e) sodium graphite reactor. Associated with Westinghouse for the 360 MW(e) PWR announced by Southern California Edison. Associated with Atomics International on engineering and design study for AEC on 300 MW and 75 MW organic moderated and cooled power plants. Engineer for the Industrial Reprocessing Group study of a private fuel reprocessing plant.

Very truly yours,
W. KENNETH DAVIS,
Vice-President.

Bechtel Corporation,
220 Bush Street, San Francisco 4,
California, USA.
6 June, 1960.

Events in Advance

Sewage Purification

OLYMPIA Ballroom, Scarborough, has been selected as the venue for this year's conference of the Institute of Sewage Purification. To mark the occasion, the Mayor and Mayoress of Scarborough, Councillor and Mrs. J. A. Kennedy, are arranging a reception for the delegates and their ladies, which will take place on the evening of 20 June and the conference proper will be held from 21 to 24 June.

After the formal opening of the proceedings by the Mayor, the President for the ensuing year, Mr. M. A. Kershaw, general manager of the West Hertfordshire Main Drainage Authority, will be installed and will deliver his presidential address. Among the papers to be discussed may be mentioned "Fuel Cells and Their Potentialities for Power Generation from Sludge Digestion Gas," by Dr. H. H. Chambers; "Two-Stage Biological Sewage Treatment in Germany," by Dr. Ing. H. Rohde; "An Ecological Approach to Some Bacteria Bed Problems," by H. A. Hawkes; and "Sewage Disposal at Sea: Recent Bacteriological and Epidemiological Studies," by Dr. B. Moore.

On the afternoon of 21 June, there will be a discussion on a symposium entitled "Progress Towards the Solution of the Synthetic Detergent Problem." This will be introduced by Dr. A. Key, senior chemical inspector to the Ministry of Housing and Local Government. In addition to the technical sessions, a number of social functions have been arranged.

Additional information about the Institute and the annual conference may be obtained from the joint secretaries, the Institute of Sewage Purification, 10 Cromwell Place, South Kensington, London, SW7 (KENsington 3885).

Exhibitions and Conferences

Institution of Mechanical Engineers, Automobile Division, Summer Gathering.—Sat., 18 June, at the Motor Industry Research Association's proving ground at Lindley, near Nuneaton. Tickets required. Apply to the secretary, Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

Handicrafts and Do It Yourself Exhibition, Eighth International.—Thurs., 8 Sept., to Fri., 23 Sept., in the Empire Hall, Olympia, London, W14. Exhibition offices: Link House, Store Street, London, WC1. Tel. MUSeum 9792.

Ultrasonic Inspection, Conference on Theory and Practice of.—Thurs., 22 Sept., to Sat., 24 Sept., at the Queen's Hotel, Cheltenham. Organised jointly by the Non-Destructive Testing Group of the Institute of Physics, the Society of Non-Destructive Examination, and the Non-Destructive Testing Society. Apply to Mr. I. M. Barnes, Materials Laboratory, de Havilland Propellers Ltd., Hatfield, Herts.

Welding Technology, School of.—Courses from Mon., 26 Sept., to Fri., 30 Sept.; Mon. and Tues., 10 and 11 Oct.; from Wed., 12 Oct., to Fri., 14 Oct.; and from Mon., 24 Oct., to Thurs., 27 Oct. Apply to the Institute of Welding, 54 Princes Gate, Exhibition Road, South Kensington, London, SW7. Tel. KNIghtsbridge 8556.

Ergonomics in Industry, Conference.—Tues., 27 Sept., to Thurs., 29 Sept., at the Connaught Rooms, Great Queen Street, London, WC2. Sponsored by the Department of Scientific and Industrial Research. Apply to Miss H. M. Clay, DSIR, 14-18 Cornwall Terrace, Regent's Park, London, NW1.

Physics of Electrostatic Forces and Their Applications, International Colloquium.—Tues., 27 Sept., to Sat., 1 Oct., at Grenoble, France. Organised by the Laboratoire d'Electrostatique et de Physique du Métal of the Centre National de la Recherche Scientifique. Apply to the secretary of the organising committee, Professor N.-J. Felici, Institut Fourier, Place du Doyen-Grosse, Grenoble (Isère), France.

Film Industry, First International Festival.—Tues., 4 Oct., to Sat., 8 Oct., in Rouen. Held under the patronage of the Council of European Industrial Federations. Festival offices: COMET, Quai de Paris, Rouen, France.

Electronics Conference, National.—Mon., 10 Oct., to Wed., 12 Oct., at the Sherman Hotel, Chicago, Ill., USA. Organised by the Institute of Radio Engineers, 1 East 79 Street, New York 21, N.Y.

Automobile Engineering, One-Year Post-Graduate Course in.—Terms: 10 Oct. to 16 Dec., 1960; 16 Jan. to 24 Mar., 1961; and 24 April to 7 July, 1961. Held at the Advanced School of Automobile Engineering, Cranfield, Beds. The School is administered by the College of Aeronautics. Apply to the Warden, College of Aeronautics, Cranfield, Bletchley, Bucks, perferably before 1 Aug. Tel. Cranfield 321.

Meetings and Papers

Association of Supervising Electrical Engineers

BRISTOL
Annual General Meeting. Bristol and West of England Branch. Grand Hotel, Bristol. Mon., 20 June, 7.45 p.m.

COVENTRY
Films on "Installing Armoured Cables," a comparison of British and American methods. East Midlands Electricity Board's Sports and Social Club, Merrick Lodge, Sandy Lane, Coventry. Fri., 24 June, 7.45 p.m.

CROYDON
"Heat Storage," by R. Jackson. South London Branch. Greyhound Hotel, High Street, Croydon. Thurs., 23 June, 8 p.m.

Institute of Petroleum

LONDON
"Exploration and Production Methods: A Symposium"; comprising "Geophysics Today," by Dr. J. McG. Bruckshaw; "Possible Improvements in Drilling," by H. D. Fanshawe; "Advances in Well Logging," by P. Threadgold; and "Partial Removal of H_2S from Crude Oil by Stripping with Natural Gas," by T. R. Shipster. Exploration and Production Group. Fri., 24 June, 10 a.m. and 2.30 p.m.

Institute of Physics

LONDON
Annual General Meeting. Tues., 5 July, 5 p.m.*

Institution of Electrical Engineers

LONDON
Conversazione. Royal Festival Hall, South Bank, SE1. Thurs., 23 June, 7.30 p.m.

Royal Institution

LONDON
"What is an Acid?" by Professor R. S. Nyholm. Salters' Lecture in Chemistry. Tues., 21 June, and Thurs., 23 June, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927)
Institute of Petroleum, 61 New Cavendish Street, London, W1. (LANgham 3583)
Institute of Physics, 47 Belgrave Square, London, SW1. (BELgravia 6111)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (COVent Garden 1871)
Royal Institution, 21 Albemarle Street, London, W1. (HYDe Park 0669)

World Power

ON MAN'S wise use of energy depends the future of the world. Sir Harold Hartley's words, spoken ten years ago, carry a special significance when applied to the constructive and destructive aspects of nuclear energy. But wisdom in the use of this new energy source is not only required to avoid self destruction; the increase in world power consumption and the disparity in its distribution make special demands on human intelligence. This years' theme for the World Power Conference, held in Madrid from 5 to 9 June, dealt with methods of solving power-shortage problems, a subject in which nuclear energy has an important part to play, as also have wind and solar energy—chosen as the symbols of this year's conference.

Changes in Consumption: Absolute and Relative

The pressure of population growth and efforts to raise the standard of living both tend to increase power consumption. Fig. 1 shows the trends and the gradual increase in the importance of nuclear energy. But the significance of nuclear energy does not solely lie in terms of total world consumption. Another important task will be to even out the present disparity in distribution. The yearly energy consumption *per capita*, averaged throughout the world, is equivalent to 1¼ tons of coal. But in certain countries the energy consumption reaches 7½ tons, while in underdeveloped countries a typical figure may be ½ ton of coal equivalent *per capita* annually. Francis L. Adams of the United States delegation stated the problem in political and economic terms: 25 per cent of the world's population now accounts for nearly 80 per cent of the world's electric energy supply; while 75 per cent of the world's population have available only 20 per cent of one of the most vital necessities of human progress. The social and political pressures to even out the appalling disparities will grow with the years, and nuclear power will have an increasing contribution to make.

Geographic and Demographic Implications

Nuclear power shares with solar and wind energy one peculiarity: they are all independent of the geographic limitations of the conventional energy resources. Sun and wind are found in varying quantities everywhere on the earth, and fuel transportation costs of nuclear power are so small compared to the overall cost of power generation that the distance of a power station from the uranium mine ceases to be an economic factor. Thus nuclear power will be as important as ploughshares in opening up new tracts of land for the world's growing population. But the impact of nuclear power will be profound even in highly industrialised countries such as Great Britain or the United States. An interesting development in the United States will be the effect of nuclear power on the transportation cost of conventional fuel. Traditionally, power in America has been transported as fuel rather than electricity, and power stations are sited near the centres of consumption. The railways, being the primary energy carriers of the country, exercised a powerful control over the cost of energy production. When the public utility companies threatened to locate power stations on the coalfield and transport energy "through wires," the railways were forced to make concessions as much as 35 cents per ton to avert the loss of business. With the further threat of nuclear power, the economic pressures on the railroads will increase. Coal prices in the United States, according to the paper by E. T. Hughes and N. C. Nelson, "The Technological and Economic Factors Affecting the Rate of Development of Nuclear Power in the United States," vary from as low as 14 to a high point of 35 cents per million Btu, with an average of 27·3 cents for the country. The target for nuclear power is competition with 35 cents fuel by 1970, and it will be up to the railroads in the United States to determine by their price policy how large an area will be affected by nuclear power.

Problems of Integration

While the need for nuclear energy will be strongest in geographical locations where other forms of energy are completely unavailable, for many years to come the largest proportion of nuclear power plant construction will occur in areas where alternative forms of energy are available. This condition brings special problems of integration to bear on the design of the plant and the whole electrical system. A typical example of the problems encountered is given by the construction of the 200 MW(e) nuclear power station CANDU as part of the Ontario Hydro Electric Power Commission's system. Ontario Hydro provides about 80 per cent of the province's energy requirements with a total primary load of 4,680 MW in 1958, generating at a load factor of about 0·62. The anticipated completion date of CANDU is 1963, and the projected utilisation is shown in Fig. 2 for three successive years. The curve shows the periods of time during which the 200 MW(e) plant could be operated economically at full capacity. The whole estimate hinges on the assurance of Atomic Energy of Canada Limited (AECL), designers of the station, that the generating costs would be equal to or less than the cost of power generated in conventional thermal plants serving the Ontario Hydro system. The implication of the study, reported by J. H. Smith of Ontario Hydro and J. S. Foster of AECL, is that it will not be economical to attain a load factor of 0·80 on the plant for the first three years of operation even if the cost of energy is competitive with thermal generation. But the ability to maintain a high load factor is one of the prime requisites of commercial nuclear power generation.

Heat Storage to the Rescue

Both underdeveloped and industrialised countries will be plagued by fluctuating electricity demand when turning to nuclear energy. The limited base load available in an electrical system is soon exhausted while in isolated installations served solely by nuclear power, the base load may be a negligible fraction of peak demand. Energy storage is the classical solution to problems of this kind, but prior to this year's World Power Conference the principal means discussed were pumped storage schemes. The primary disadvantage of pumped storage is that capital cost, as in the case of nuclear power, is very high compared to the cost of a peak-load thermal power station. An attractive alternative is heat storage and two dissimilar schemes were discussed by the Austrian and German delegations.

Climbing the Peaks

In areas where a considerable portion of the electrical consumption is devoted to heating—industrial or domestic—there is a possibility of storing heat at the point of consumption. Schemes of this type have been adopted by most countries where the problem is applicable, and block storage heaters are growing in popularity in the United Kingdom. But thermal storage at the consumers' premises is only a partial and not particularly lucrative solution. Block storage consumes more power for the same effect than the conventional means of heating, and the customer can be induced to accept this only by offering drastic reductions in charges during off-peak periods. If thermal storage can be effected at the power plant prior to conversion to electricity, the price reduction can be avoided. Such a solution is not applicable to conventional thermal plants because the turbogenerating equipment still has to be designed to supply the peak load. But in a nuclear plant the major contribution to the capital cost comes from the reactor and steam-raising equipment, and thermal storage would theoretically permit operating a 1,000 MW(t) reactor with a 500 MW(e) turbine installation, that is half the required size of reactor. Fig. 3 shows the elimination of peaking as a result of storage: the areas enclosed by the load curves for the supply network and prime mover represent storage.

Feed Water or Pressure Drop Storage

Two alternative thermal storage schemes have been put forward in the past. Neither gained much popularity because large storage vessels were required for which neither the engineering nor the fabrication methods had been developed. But many reactor types require site erection of pressure vessels of large volume either as pressure or containment vessels, so that today both the technology and the facilities exist for the solution of thermal storage. The two schemes formerly put forward were called feed-water storage and pressure-drop storage. Hot water under high pressure is used in both cases, charged with back pressure steam during periods of low demand. In the first method the stored hot water is used for feed while the extraction from the turbine for feed water heating is reduced to zero. The mode of operation clearly defines the limits of storage with this method, since the maximum gain in output is reached when extraction becomes zero.

Combined Scheme

Although of lower conversion efficiency, pressure-drop storage does not suffer from capacity limitations. In this method the pressurised hot water is flashed into steam and utilised in turbines suitable for wet steam conditions. Dr. Fritz and Dr. Ferdinand Marguerre, in their paper "The Applications of Heat Storage in Nuclear and Conventional Power Stations," suggest combining the two schemes in a single pressure vessel. With the combined arrangement the power output can be increased by as much as 35 per cent, while the cost of installation, under German contract conditions, would be about £14 per installed kilowatt. Although a 35 per cent increase in power output starting from base load is not generally sufficient to absorb the peak load of a system, the range of application in which nuclear power might become competitive is considerably increased.

Economical Hybrids

Another paper dealing with thermal storage and hybrid plants was by F. A. P. M. Theunissen of the Netherlands, entitled "The Economic Use of Conventional and Nuclear Fuel in an Electricity Supply System." Theunissen attempted to prove, with figures, that were vigorously attacked during the meeting, that hybrid stations were invariably more economical than purely nuclear installations. He improved on Marguerre by suggesting that thermal

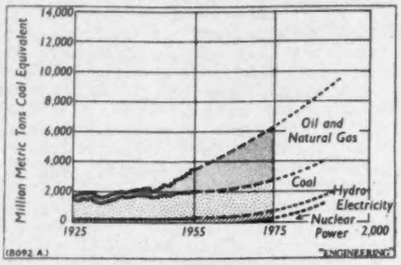


Fig. 1 The role of nuclear energy in supplying a growing demand.

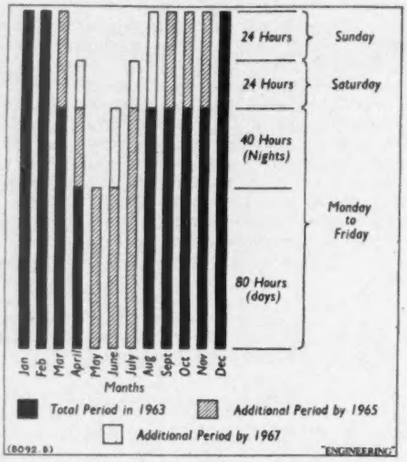


Fig. 2 Utilisation of a 200 MW(e) nuclear power station in an extensive electrical system comprising hydroelectric and thermal generating capacity.

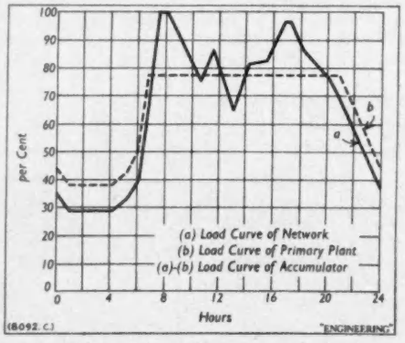


Fig. 3 Effect of thermal storage on the load curve of a nuclear power station.

storage should be used in conjunction with hybrid stations only, but he quoted $80 per installed kilowatt as a representative figure for the capital cost of thermal storage, about twice as high as the figure of Marguerre. Theunissen mentioned two interesting aspects of hybrid stations. For reasons of national prestige a pure nuclear station was preferable. Secondly, hybrid stations made siting even more difficult because a cheap supply of fossil fuel must be at hand in addition to the safety requirements.

Notes and News

Gas Turbine Cycle for Helium-Cooled Reactor

Compared with the turbo-machinery of a pressurised water reactor, the closed-cycle gas-turbine installation designed for the marine gas-cooled reactor project (MGCR) will save 30 per cent in installed volume. Consisting of three basic units—high-pressure turbine and high-pressure compressor, coupled directly to the low-pressure compressor, and on a separate shaft the power turbine—the turbo-machinery is extremely compact. Theoretical cycle efficiency operating with a maximum helium temperature of 1,300° F at 800 lb per sq. in is 31 per cent, with a continuous rating of 22,600 h.p. The machinery, designed by Westinghouse, was described in a paper by P. A. Berman, read to the Gas-Cooled Reactor Symposium, Philadelphia, February, 1960. (*Nuclear News*, vol. 2, No. 3, March, 1960.)

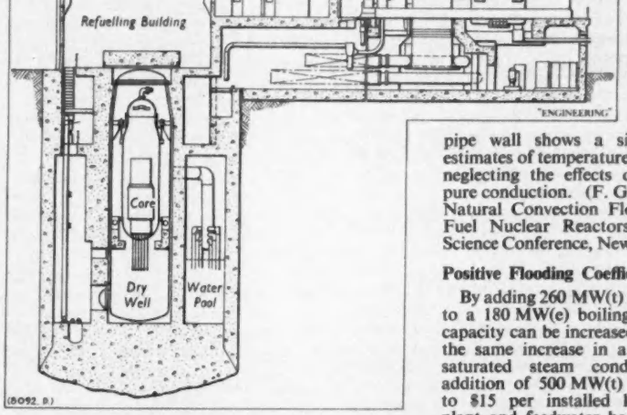


Fig. 4 Application of cold water pressure suppression for the containment of pressurised or boiling water reactors.

Free Water Pressure Suppression at Humboldt Bay

The method of using free cold water between the pressure vessel and the containment vessel of water reactors to reduce the pressure rise and containment requirements in case of a reactor accident has been investigated by Sargent and Lundy (Atomic Review, 27 May '60) and the General Electric Company. It now appears that the Humboldt Bay plant of the Pacific Gas and Electric Company will be the first application of the technique. Fig. 4 shows a cross-section of the plant. The reactor is partially buried to reduce the hazard of a reactor that will be built in a holiday area of California. Surrounding the dry-well of the reactor vessel is the concrete containment structure with provision of free water in a pool. In case of reactor-vessel rupture the flash steam expands through a pipe which forces it to pass through the water pool. It is claimed that not only is the subsequent pressure rise reduced significantly, but the water pool acts as a scrubber and removes all but the noble gas fission products from the reactor steam.

Moderator Control in 4th Generation Water Reactor

At a substantial increase in size and modest advances in technology, a fourth generation of water reactors can be added to the Nautilus-Shippingport, EBWR-Yankee, Dresden, Indian Point line of development. The technical advances are designed to reduce the hot channel factors from 5·17 in Yankee to around 3·2, accomplished by: control rod programming to eliminate flux and power peaking over the core's lifetime; three-region core with maximum enrichment in the outside; fuel-bearing followers for the control rods; and the technique of moderator flux control. Dissolved poisons or heavy-water mixed with the moderator (moderator flux control) is now the subject of a major development effort and is essential for long-lived large cores of the future, where a limit exists on the excess reactivity that can be limited by control rods. (W. E. Shoupp and J. H. Wright: Advanced Water Reactor Systems, Nuclear Engineering and Science Conference, New York, April, 1960, paper 43.)

Liquid Fuel Convection Currents in Small Pipes

A knowledge of natural convection currents in liquid fuels is essential to the design of "mobile-fuel" reactors. Natural convection is complicated by internal heat generation and smallness of the flow passages, but must be solved in order to assess the possibility of mass transfer of containment material, the axial distribution of heat flux across the container walls, the possibility of fission gas hold-up, and the temperature distribution along the fuel channel. Natural convection flow may reach 100 ft per hour even in a sealed single fuel-tube of approximately 50 mills diameter. The radial temperature difference—centreline to wall—is uniform along the tube except for a slight increase at the top and decrease at the bottom. The heat flux across the pipe wall shows a similar variation. Adequate estimates of temperature differentials can be obtained, neglecting the effects of convection and assuming pure conduction. (F. G. Hammit and E. M. Brower: Natural Convection Flow in Liquid-Metal Mobile-Fuel Nuclear Reactors, Nuclear Engineering and Science Conference, New York, April, 1960, paper 58.)

Positive Flooding Coefficient of Nuclear Superheat

By adding 260 MW(t) nuclear superheating capacity to a 180 MW(e) boiling-water plant, the generating capacity can be increased to 325 MW(e). To achieve the same increase in a boiling-water reactor using saturated steam conditions would require the addition of 500 MW(t) capacity. A saving of $10 to $15 per installed kilowatt of turbogenerating plant and feedwater heating equipment also results from improved steam conditions possible through superheating. The requirements of core composition are negative void and temperature coefficients, which result in a positive flooding coefficient. In General Electric's study a water-to-fuel ratio of 1·6 was chosen, giving negative void and temperature, and a suitably small positive flooding coefficient. Flooding of all superheater channels results in a 2 per cent loss of reactivity. (E. L. Zebroski, K. M. Horst and P. G. Aline: Nuclear Superheaters for Boiling Water Reactors, Nuclear Engineering and Science Conference, New York, April, 1960, paper 46.)

Pressure Changes in Liquid-Vapour Systems

Instead of trial and error, direct graphical and analytical methods have been developed to solve pressure changes in a two-phase water system, applicable both to reactor and steam engineering. The graphical method involves solving for the final volume and entering a chart of specific volume versus specific internal energy to obtain the final pressure. The analytical method has been developed for computer applications by linear approximations over a limited range of temperature and pressure. (W. H. Comtois: Determination of Pressure in a Two-Phase Water System, Nuclear Engineering and Science Conference, New York, April, 1960, paper 56.)

Regenerative Poison Gives Unprecedented Burnup

"Natural" plutonium coming from the civil reactors will have approximate isotopic composition of 80 per cent plutonium 239, 16 per cent plutonium 240 and 4 per cent plutonium 241. In an epithermal neutron flux the plutonium 240 content behaves as a burnable and regenerative poison, being transformed into the fissile isotope 241 by neutron capture. As a result of continuous enrichment during operation, a reactor fuelled with an alloy containing 66 atoms of steel for each atom of plutonium could operate to a burnup of 680,000 MWD per tonne before the reactivity falls below 1·2. A suitable reactor would use graphite moderator to achieve the high epithermal flux fraction necessary. As a result of the extremely high burnup the fuelling costs of such a reactor should be low, and the need for fuel reprocessing can be avoided. Work at the atomic energy section of the British Shipbuilding Research Association is centred on graphite-steel systems, and promising methods have been discovered to make the temperature coefficient of reactivity negative at high temperatures. The cost of plutonium is uncertain at present, but estimated on the basis of equivalence with uranium 235 as enrichment material, a figure of £5 per gramme has been quoted. (J. E. Richards: Nuclear Power for Ship Propulsion, paper read to the Institute of Fuel, 9 March, 1960, abstracted in the British Shipbuilding Research Association *Journal*, vol. 15, No. 4, April, 1960.)

Niobium for High Temperatures

Whether called niobium or columbium, the forty-first element is likely to play an important role as a reactor material when operating temperatures reach the 1,850° to 2,400° F range. Of possible reactor materials—molybdenum, tungsten, tantalum, vanadium or niobium—the latter has the best combination of nuclear and structural properties, can be readily sintered, forged, swaged, rolled, machined and welded, and is compatible with most uranium-based fuel materials. Chief disadvantages are a high affinity both for oxygen and dollars. (*Battelle Technical Review*, vol. 9, No. 3, March, 1960.)

Alloys of Plutonium

Two members of the UKAEA research group have tackled the chemical analysis of ternary alloys of plutonium with uranium and molybdenum in an AERE report. A procedure for the determination of plutonium, uranium and molybdenum in their ternary alloys consists of plutonium separation from an acid solution of the alloy by absorption as the nitrate complex on a column of anion exchange resin. The uranium and molybdenum are recovered from the column effluent and determined without further separation. The plutonium is recovered from the column by elution with hydrodylamine hydrochloride. Determinations use absorptiometry. ("The Chemical Analysis of Ternary Alloys of Plutonium with Uranium and Molybdenum," E. Foster and G. Phillips, AERE, R3147, 2*s* 6*d*)

Reactivity Calculations

A declassified report, dating some years back, gives a formula for the change of pile reactivity during operation due to destruction of uranium isotopes and build-up of neptunium and plutonium. These results apply to natural or enriched reactors, but effects due to plutonium 240 are not considered although ways of calculating this are outlined. For a given lattice pitch, enrichment adversely affects reactivity changes due to irradiation. Poisoning, temperature and depletion considerations are ignored. ("The Change in Reactivity of a Pile During Operation" J. Codd and J. F. Hill, AERE R/R 2387, 3*s*.)

Experimental Performance of Pluto

Thermal, epithermal and fission neutron fluxes have been measured and plotted for the PLUTO reactor of the UKAEA in order to assay the performance of irradiation facilities and experimental holes in the reactor. The measurements were made with the experimental holes unloaded and at a power level of 10 MW, or substantially lower than the design power of the reactor. Results are presented as a set of curves normalised relative to the flux in the scanning position of fuel element C3. For powers other than 10 MW the fluxes may be scaled directly in the ratio of power if allowance is made in the case of thermal flux for fuel burnup. Apart from changes due to control arm movement, thermal fluxes are proportional to power divided by total fuel loading. ("Physics Measurements During the Commissioning of Pluto," C. J. England and S. B. Wright, AERE Report R3153, 12*s*)

Flywheels for Nimrod

Two 35 ton flywheels coupled to the 120 MVA motor-alternator set of Nimrod's magnet supply will serve to even out power fluctuations as the 7 GeV synchrotron sends its proton pulses to chase the speed of light. The motor alternator set will be supplied by English Electric, while the flywheels come from Buckley and Taylor.

Appointments to the Authority

Mr. John Pears, chartered accountant, has been appointed as part-time member of the United Kingdom Atomic Energy Authority. Sir Alan Hitchman, responsible for external relations and commercial policy, will also take over the responsibilities for finance and administration from Sir Donald Perrott, retiring at the end of July.

Human Element

Electronic Thin Red Line

EXPENSIVE as electronic devices are they are probably the only thing that can save bank account holders from rising charges.

The increasing number of cheques being written are already giving the banks certain staff headaches. Once the hourly wage workers are handed weekly cheques by the million the present position will become untenable overnight.

Down at the Hayes, Middlesex, headquarters of Electric and Musical Industries, FRED, the company's Figure Reading Electronic Device, modified for automatic cheque handling, was last week demonstrated to both British and European bankers.

Developed as a numeral reading machine for use with bank cheques and similar business purposes, FRED sorts cheques ranging in size from 6 by 3 in to 8 by 4 in. The relevant data on the client's cheque, serial number, branch number, identity and amount can all be coded along the bottom edge in the special FRED numerals.

Adaptation of a bar code system is usually simple enough. In the case of the complicated shapes of conventional Arabic numerals it has been necessary to create a five element bar code. The typeface this produces is based on an existing printers' fount known as Broadway, which makes for easy visual recognition.

Firm's Representatives Adopt Car Safety Belts

Clocking averages of 40,000 miles a year or more company representatives have a greater chance than many of being involved in road accidents.

Now, after more than a year of trials, the Talbot Stead Tube Company, of Walsall, has decided to fit all its representatives' cars with safety harness. The company is not in any way connected with manufacturers or suppliers of such safety equipment and its action stands as a sign post to at least one way in which the life-saving car safety belt may be given wider acceptance.

The recent trials in Hyde Park left no doubt about the efficiency of quite simple safety harness in preventing crushing of the skull in collision with the instrument board.

Scots Coal Board Director to Lead Mining Engineers

The reconstruction director for the Scottish Division of the National Coal Board, Mr. Robert A. Moore, is to be President of the Institition of Mining Engineers for the session 1961-62.

Mr. Moore's grandfather was the first Inspector of Mines in Scotland and his father, the late Dr. Robert Thomas Moore, presided over the Institution in 1908-9.

The new President-elect worked in coal mines in England, Wales and Scotland before gaining his first-class colliery manager's certificate in 1932.

In the same year, he joined the firm of A. G. Moore, becoming general manager in 1936, and chairman in 1938. In 1956, he became production director of the Scottish Division of the National Coal Board and, in 1958, its reconstruction director.

Steel Company Roll Call

Mr. M. A. Fiennes, chairman and previously managing director of the Davy-United subsidiary Davy and United Roll Foundry, of Billingham, Co. Durham, has relinquished the managing directorship to Mr. Herbert H. Utley.

Mr. Utley's career reads like the roll of honour of the steel industry. Leaving the applied science department of Sheffield University he began as an engineering apprentice with the United Steel companies, transferring in 1931 to the central fuel department of the company.

Nine years later he moved to the Skinningrove Iron Company as night superintendent and two years from that appointment was assistant works manager.

Joining Dorman Long as assistant works manager of their Cleveland works in 1945, Mr. Utley became works manager in 1954. He joined Davy and United Roll Foundry as general manager and a director in 1957.

Dissent at Borough on Thermodynamics

Controversy is a word of wide meaning, spreading from a head-on collision to polite dissent. Somewhere between these comes the argument at the Borough Polytechnic, London, aroused in a recent post-graduate course on the "Modern Treatment of Engineering Thermodynamics."

The discussion turned on Professor Keenan's thesis that thermodynamics is for something more than the solution of problems. That instead it should be taught and studied in a vigorous analytical way if it is to develop as a logical and consistent discipline equipping engineers to make new developments.

Perhaps more than any other the engineering school of Imperial College has advocated this new approach. But not to the exclusion of other opinions. Guest lecturers, Mr. E. H. Cole, Imperial College, and Mr. W. B. Gosney, King's College (London), were followed by lively differences—disagreements may be a better word—over the application of Professor Keenan's way of developing thermodynamics.

Australian's Investment Tour of Britain

A one-man tour of British industry and financial interests has been conducted by the managing director of one of Australia's largest independent tool making companies, S.A. Tool and Gauge, of Adelaide—Mr. G. F. Anderson.

The products with which Mr. Anderson has been most concerned included home and office air conditioning, small hydraulic equipment, aircraft components, outboard motors, standard punches and milling cutters. In all of these he has been looking for licensing arrangements for production in Australia.

The second string in Mr. Anderson's bow was the information he brought from Australia for smaller United Kingdom companies who may be considering opening up there. The two deterrent factors in contemplating such a move are those of cost and availability of tools in a country expanding at high speed. The outlay for even a small company setting up its own tool room and die making and jig shop runs upwards from £100,000. Something of a bottle-neck can be encountered in tools when the demand is general and expanding.

His own company developed from munition production in 1940 and has now developed by persistent diversification and expansion of capacity. From London, Mr. Anderson and his wife have gone on to the United States.

Storm Warning from Seaside Socialists

Taking a crack at the Trade Union Congress is one of the most popular blood sports at annual trade union conferences. Mr. Ian Mikardo, the former Labour M.P., summed up these criticisms in this way at Clacton, Essex, last week where the Association of Supervisory Staffs, Executives and Technicians were engaged in passing a resolution calling on the TUC to be more militant and not to interfere with its affiliated unions.

Much more serious is the contagious upheaval within the Labour Party which appears to be moving towards a crisis. Some of the replies to Mr. Woodrow Wyatt's attack on Mr. Frank Cousins, the leader of the Transport and General Workers' Union, show that what may soon be at stake is the keystone of the Labour party-trade union organisation.

The party's annual conference passes resolutions on which the trade union multi-million vote exceeds many times over that of the comparatively puny constituency parties. It matters not at all in the present battle that Mr. Wyatt, an MP far out on the right of the party, should imply criticism of the block vote while the constituency parties, who feel disfranchised by the weight of union voting, are mostly well over to the left.

Ignoring Resolutions

The Conservative party leader can be seen on various occasions in past years to have effectively ignored resolutions of his party's annual conference. Every moment of Labour parliamentary or trade union is conducted in the full glare of publicity and if annual conference resolutions are no more binding, as Lord Attlee demonstrated, their being flaunted is made much more noticeable.

When Mr. Shinwell, the veteran Labour MP, says darkly that in 1931 the trade unions saved the party, and may have to do so again, he sets a limit to the battlefield.

Many observers have noted how some moderate trade union leaders appear to have lost interest in the outcome of the Labour party's travail. Mr. Shinwell's remark limits this disillusion to the narrower field of the way the party is being conducted.

If there is to be a resolution of the relations between the party's leadership and the unions this year, two solutions seem likely. Either the unions will continue with their decisive voice, in which case association of the Labour party with a working class without privileges or responsibilities will continue, or trade union influence will decline, which will let in the socialist revivalists on the left with nationalisation and neutralism on their banners.

Italy's Problem of Partial Prosperity

The fast growing industrial activities of Italy have produced the unlikely situation of a shortage of labour in a country that almost more than any other in Europe is associated with unemployment.

Like the opportunities, the shortage is highly specialised. Trained engineers, technicians and skilled labour are not available in the numbers needed in the north. The great Fiat works have the prestige to attract men from smaller factories all over northern Italy.

The result is a situation, not dissimilar from that predicted last year by OEEC, where the limiting factor in Western Europe is one of suitable labour. This is a position which among its effects includes a sharpening of the contrast between the lively productive North and the barren, poverty ridden South, which accounts for a great many of Italy's 1,700,000 unemployed.

Many of these are men only experienced in work on the land. But just as the shortage of engineers and graduates joining industry means that 40,000 a year and not the present 20,000 graduates will be needed from the universities by 1975, so something like another 2 million workers will be needed in industry.

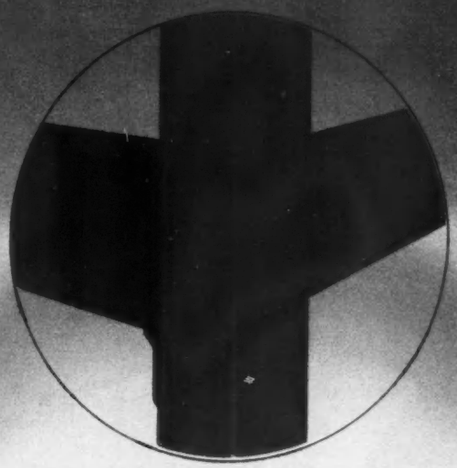
Faced with the choice between taking new industrial plant to the Mezzogiorno (the South) or leaving the enticement of finding work to move the unemployed to the industrialised North, the result is likely to be a compromise. Some industry will spring up around the steelworks the Government are determined to create in the so far non-industrial South. A rather larger gain in jobs will probably take place in already prosperous Milan and Turin.

Growing Popularity of Private Pools

Nothing yet equals the number of advertisements the *Radio Times* and certain other popular journals carry for sheds, hen houses and greenhouses. But the beginnings of rivalry are apparent with advertisements for home do-it-yourself swimming pools—of a size which will compel the owner to swim in a curve rather tighter than that of the bowled goldfish.

They order these things rather differently in America. There it is reported that the number of "back-yard swim pools" owned by the go-ahead residents of California is down from a half to a quarter of all those in the United States. A popular size is about 20 by 40 ft and the larger number are made by laying a fabric, often of steel, and then pouring concrete over it or spraying the skin with concrete.

A swimming pool industry, with some firms operating on a national scale, has sprung into life in the States and only at the humblest end is there found the above ground temporary structure. Credit buying has brought swimming pools within reach of those who have sufficient room in the garden and are in the two or three car class.



...stronger....cheaper

The high quality of British structural steel is now recognized by the sanctioning of higher working stresses. More efficient columns and beams, new methods of design and fabrication—all combine to reduce the amount of steel and labour required, and thereby to reduce the cost. The result: an overall saving.

CHEAPER

These advances mean that the finished structure is cheaper, because steel and labour are saved.

STRONGER: A higher safe working stress is now recognized, again reducing the amount of steel needed for a given job.

FURTHER SAVINGS: Fire-proof encasement, hitherto calculated as a burden on the steelwork, is now accepted as contributing to its strength, so that columns can be slimmer, saving steel and labour.

STEEL-FRAMED BUILDINGS
GIVE GREAT ARCHITECTURAL SCOPE WITH UNQUESTIONED STRUCTURAL SECURITY

BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION, WESTMINSTER, S.W.1

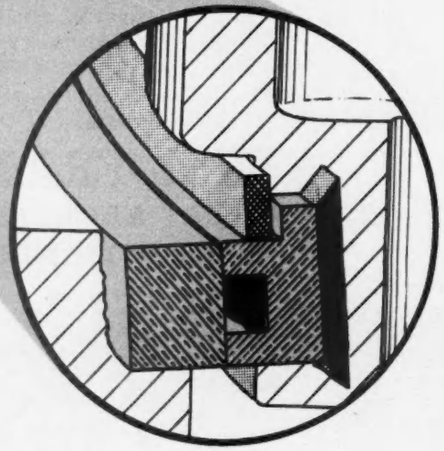
B·C·S·A STEEL

The Oil Tanker Valve of the Future

Proved under severe test conditions and by actual service trials, the Blakeborough "Flexi-Ring" principle has emerged as the one complete answer to gate valve problems on oil cargo duty. In performance it sets a new standard for the future, not only in the tanker field but for a variety of other applications where conditions of similar difficulty obtain.

BLAKEBOROUGH FLEXI-RING GATE VALVE

- Dead-tight shut-off on both upstream and downstream faces.
- Leak-proof seating maintained despite grit, scale, etc., or body distortion due to pipe movements.
- Ease of operation.
- Simple replacement of "Flexi-Ring" components if ever necessary.
- Enhanced durability.



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Machine Tool Firms React to Freer Trade

On 1 July tariff reductions are due in both the Six and Seven. Western Germany will have the advantage in export markets of mass production for the big European Common Market.

By Richard Bailey

THE European machine tool business is essentially a small-scale industry working for thousands of different customers, the majority of whom want a product made to meet their own particular requirements. Trade in machine tools is therefore not highly competitive in the ordinary sense of the term. Manufacturers go on supplying machine tools to the same customers because in many cases the products of other makers just would not fit into existing production lines.

How is this highly individual, and, as some may think, conservative, industry likely to be affected by freer trade in Europe? How does the setting up of the two new trading groups, the Common Market of the Six, and the EFTA (European Free Trade Association) of the Seven, affect the British firms in the industry?

STATE OF COMMON MARKET

In the Common Market itself, Germany, France, Italy, Holland and Belgium all have important machine-tool industries. Between them they account for 24 per cent in value of world production compared with 35 per cent by the United States. The Common Market output is worth about £243 million and weighs around 340,000 tons. Table I lists percentages of world production, taking the members of the Common Market together.

TABLE I.—*Percentages of World Production*

USA	34
Common Market	24
USSR and China	23
United Kingdom	9
Switzerland	4
Others	6

At the present time in the Common Market there is considerable trade in machine tools, both between members and with countries outside. Germany, which is traditionally a big exporter, nevertheless imports some American, British and Swiss machine tools, especially gear-cutting machines, heavy presses and transfer machines. In 1957, Germany exported 110,000 tons of machine tools worth £76 million, representing half the national output. France was the best customer, but Britain with £7·6 million worth came second. The German industry comprises some 500 concerns employing a total of 87,000 workers. The most interesting feature of the industry is the very wide variety of its products covering practically the whole range of machine tools. Even so, German industrialists buy about 12 per cent of the machine tools they need from abroad.

The second biggest producer among the Six, but a long way behind Germany, is France. In 1958, France produced 58,000 tons of machine tools valued at £56·5 million. This figure was by no means sufficient to meet the needs of French industry and some £23 million worth of machine tools were imported. Britain, number four among France's suppliers, accounted for £2 million worth.

The high level of imports is explained by the fact that a number of types of machine tool are not manufactured at all in France. The actual numbers imported of some types are very small and there is considerable argument among French manufacturers on the wisdom of depending on imports for supplies of these tools. The very high rate of investment in French industry over the past ten to fifteen years has been a major reason for the considerable machine-tool imports. The other side of the picture is that France exported 8,000 tons of machine tools in 1958, worth some £5·8 million. The biggest customer was Spain (£600 000), followed by Britain and Germany, both taking about £425,000 worth.

In Italy the machine-tool industry has developed rapidly since the war. Some of the producers are on a very small scale indeed, but some of the biggest concerns in the country, including Fiat and Olivetti, have important machine-tool making factories. The big handicap facing the industry is that the home market for certain types of tool is very small so that imports are high in relation to sales. In 1958 some 15,200 tons of machine tools, valued at £13 million were imported. The Italian manufacturers have concentrated on a small range of the less complicated types of machine tool for export to the countries of Asia and Africa. In fact, Italy has specialised in meeting the machine-tool needs of the underdeveloped countries. So far as trade with Britain is concerned, Italy bought some £825,000 worth of machine tools from us in 1958, and sold us some £300,000 worth.

Belgium and Luxembourg between them have some 60 machine-tool makers, turning out 9,000 tons a year worth some £6 million. With a restricted home market the Belgian manufacturers look abroad for their outlets. Exports in 1958 were of the order of 7,000 tons, valued at £4·5 million. The principal purchasers were France, Germany, Holland and Italy. Imports valued at £5 million came from Germany (£2·25 million), Britain (£500,000), Switzerland (£500,000), France (£350,000), Holland (£300,000) and elsewhere.

The Dutch machine-tool industry has the peculiarity that both imports and exports are greater than production. This comes about as Holland is a trading centre for the industry and handles machine tools from several foreign countries. In addition, a number of American companies manufacture under licence there.

The amount of trade between members of the Common Market is shown in Table III. From this it is clear that Germany, the biggest producer, is the least dependent on Community sales. The rest all draw over half their imports from other member countries.

The reduction in tariffs and the liberalisation of quotas will undoubtedly lead to an increase in trade between the Six. The eventual Common Market tariff on metalworking machine tools was agreed at from 8 to 10 per cent, according to the tool, against the British rate of 10 per cent.

SEVEN CUT TARIFFS

British trade in machine tools with the EFTA countries is largely with Switzerland, Sweden, Denmark and Austria. Imports from EFTA of machine tools for working metals in 1958, in metric tons, were: Austria 114 tons, Denmark 38 tons, Norway 13 tons, Sweden 555 tons and Switzerland 1,896 tons. Exports to the EFTA amounted to: Austria 100 tons, Denmark 376 tons and Sweden 416 tons. The figures for Norway and Switzerland were not available.

In terms of value the picture is much the same. Imports in thousands of US dollars were as follows: from Austria 265, Denmark 94, Norway 42, Sweden 1,507 and Switzerland 7,714. On the export side, in thousands of US dollars, Britain's exports were: Austria 118, Denmark 791, Norway 284, Portugal 137 and Sweden 690. On metalworking machine tools the UK tariff is now 10 per cent and for trade with the EFTA countries this is due to be reduced by a fifth to 8 per cent on 1 July. The external tariff of the Six varies from 8 to 12 per cent, according to the tool.

How is British trade in machine tools likely to be affected by the new groupings? The industry is hard pressed just now to meet the demands of the customers it already has. And to some extent producers on the Continent are experiencing the same difficulty at the present. Exported British machine tools have tended to be of lower value than those sold at home. One effect of setting up the Common Market will be to make it less easy to sell tools in the Six in competition with those made inside the tariff wall. It may very well be, therefore, that opportunities for exports to the Common Market countries will be increasingly for the more expensive types of machine tool.

MORE COMPETITION

For trade with the countries of the EFTA the reduction of tariffs will make British machine tools better able to compete with those from the Community. The same will be true for those from Switzerland and Sweden, however, and as the EFTA countries do not present a big market for machine tools the advantage to the British industry is not likely to be very great. The British market, as the largest outlet for exports from the other EFTA countries, will be the scene of increasing competition as tariff cuts take effect after 1 July.

These views were borne out by a number of leading firms in the machine tool industry who were asked to reply to a short questionnaire conducted for ENGINEERING.

All ten firms considered were exporting machine tools to countries in both the Common Market and the EFTA before the discussions on freer trade in Europe started. In all cases but two where a figure was given, the EFTA was reported to take a much smaller proportion of total exports than the Six. Asked which European country was regarded as their principal competitor, all the firms answering gave Western Germany. No other Continental producer was mentioned. Several firms agreed with the view that Western Germany would have an advantage now in third markets outside the Six and Seven, as increased sales in the Common Market would make possible mass production.

What does all this add up to? So far a individual firms are concerned, it all depends on the type of machine tool they are making and how well they do their job. Technical trends as well as tariff changes are working against the small old-fashioned firm in the export market. But well equipped efficient firms with a fairly wide range of products should have little to fear. Certainly the new trading groups have had no big effects on the industry so far. But freer trade will bring in more cheaply not only special tools that are not made here at all, but standard tools as well.

Some rationalisation of the industry may prove necessary. Companies may also be inclined to seek new partners within the Common Market, looking particularly, perhaps, to countries such as Holland where the tax structure is similar to our own. As the tariffs come down in the years ahead it is likely that fewer and larger firms will be the rule.

There is every reason to suppose that the total level of production and of exports will continue to rise, provided the present high level of industrial investment and activity is maintained both in Europe and the United Kingdom.

TABLE II.—*Trade Between the Six in Machine Tools*

Imports	Germany	France	Holland	Italy	Belgium–Luxembourg
From Common Market countries (£ million) ..	1·5	11·25	5	6·5	3·25
As percentage of total machine tool imports ..	9	50	58	50	66
Exports					
To other Common Market countries (£ million) ..	22	1·25	1·25	2	2·25
As percentage of total machine tool exports	28	20	53	23	50

International Machine Tool Exhibition, London 25 June—8 July

In the four years that have passed since the last London Machine Tool Exhibition there have been many changes. Notably the advances have been in the field of automatic control, with tapes supplying the information. There have, also been several developments of the sequence programme control arrangements and some examples will be on show. Otherwise the main tendency seems to have been to make machines more generally useful and on the whole less confined to a single work cycle.

With around 400 stands, this year's display is one of the largest. It is truly international, more than ever before, as many foreign firms are exhibiting directly, apart from the many represented by machines on the stands of agents. In this issue there are special articles dealing both with technical aspects of machine tool design and with the industry in Europe as a whole. On this and the next five pages some of the exhibits themselves are described.

ROUTER

Articulated Arm

THE type LC6 is a general purpose router with an articulated arm that can be rotated through a full 360°.

The machine is fitted with a 5 h.p. router head running at 12,000 r.p.m. and the depth setting is power operated from trigger controls on the operating handles. It is arranged to operate in conjunction with preset depth stops. There are both fast and slow approach to give precision depth settings. For roughing cuts the head may be brought down on the trigger controls to any desired position where it is automatically locked. The head retracts to the top position automatically at high speed from a trigger control on the operating handles.

The table area covered is 2 ft by 2 ft on the main table, or alternatively with table fixed at 90° to the standard it will cover an area of 2 ft by 3 ft. The main table can be canted to the vertical to both left and right. Table height is variable over 8 in.

The machine is designed to cover a large part of the work now being performed on the larger LC machine, but the built-in rise and fall and canting action of the table will give a cheaper set-up than the additional tables and slides of the earlier models. As an alternative the machine can be supplied with a 10½/12 h.p. routing head and frequency changer, and with spindle speeds from 6,000 to 18,000 r.p.m. *Wadkin Limited, Green Lane Works, Leicester.*

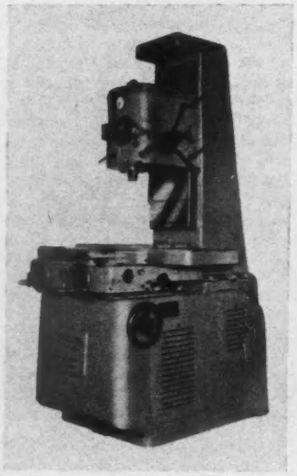
JIG BORER

Coordinate Table

USING a direct reading optical system, the Perrin jig borer is fitted with a coordinate work table.

The working surface of the table is 19½ in by 11 in and an accuracy of 0·0001 in is given by the optical scales. It is claimed that these are very simple to use in normal room lighting and do not require the operator to look through special eyepieces. The scales can be read at a distance of 3 ft without parallax errors. The table itself is controlled by two handwheels with subsequent adjustment by two conveniently placed knobs.

The spindle runs in roller bearings and is driven through a Powergrip toothed belt. The speed is selected by a Variator and a two speed gearbox giving a range between 50 and 3,200 r.p.m. Indication is by an electric tachometer in the spindle head. Power feed is selected by a handwheel on the head and an automatic trip is fitted for both up and down movements. Motor powered rise and fall can be fitted. An automatic positioning device has been developed for use with the machine for repetition work. Electrical gear is housed in the base. *Acbars Limited, 57a Holborn Viaduct, London, EC1.*



TURRET LATHE

Hydraulic Actuation

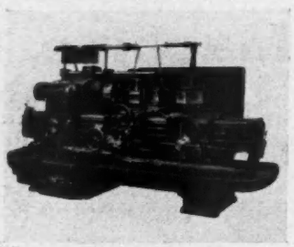
THE Prelector turret lathe differs from the standard No. 7 machine in that the gear changing, speed selection and direction of rotation can be pre-selected by means of two dials at the left hand of the operator.

The changes are made under hydraulic power. Actual declutching is effected by a single lever which by means of mechanical advantage renders the operation very easy. The capacity of the machine is the same as that of the standard No. 7, that is it will take bar up to 2 in diameter and has a swing over the bed of 16 in. The single speed motor gives twelve spindle speeds ranging from 25 to 1,000 r.p.m., sufficient to cover most normal machining requirements.

There are ten rates of feed to the intermediate saddle which has the full surfacing, sliding and screw cutting motions. The hexagon turret saddle also has ten rates of feed. Quick power traverse to the turret saddle is incorporated.

The machine on exhibition will be equipped with a hydraulic copy turning attachment for machining a steel shaft. It will thus be demonstrating hydraulic copy turning being performed on a standard turret lathe and the advantages that can be gained therefrom.

The standard No. 7 has a 4⅛ in diameter hole through the spindle and has a single speed motor giving a choice of speeds from 26 to 536 r.p.m. for heavy duty, 37 to 750 r.p.m. for normal work and 50 to 1,000 r.p.m. for high speed work. The machines are mounted on a heavy bed with a tray to catch spillage, and there is provision for coolant supply. *H. W. Ward and Company Limited, Dale Road, Selly Oak, Birmingham 29.*



CROPPER AND POINTER

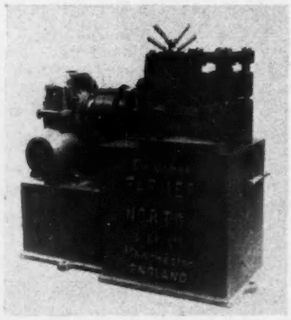
Roll Type

DESIGNED specifically for preparing ferrous and non-ferrous strip prior to drawing is a new cropping and pointing machine.

The machine has capacity for strip (in coil or length) of 1¼ in wide by ⅛ in thick, and will produce a minimum point thickness of 0·06 in. The maximum length of point formed is 9 in. The rolls run at 42 r.p.m. and the cropping head works at 42 strokes per minute. Power is supplied by a 10 h.p. motor.

The pointing rolls consist of a pair of hardened forged alloy steel rolls, the upper being adjustable to give the desired point thickness and provided with a setting scale and adjustable back stop for controlling the length of point. The cropping head is driven by means of a connecting link and eccentric mechanism designed to withstand the heavy duty. The cropping blades are made of hardened and ground alloy steel, the stationary blade being made adjustable. A simple adjustment is also provided to allow for stock width variations.

The drive is taken from the high torque motor through a combined coupling and flywheel assembly to a self-contained worm gear reduction unit. Thence it goes by a flexible shear pin coupling and gearing to each of the pointing rolls and to the cropping head. The main frame of the machine is cast iron and the cropping head and roll housing is cast steel. *Sir James Farmer Norton and Company Limited, Adelphi Iron Works, Salford 3, Manchester.*



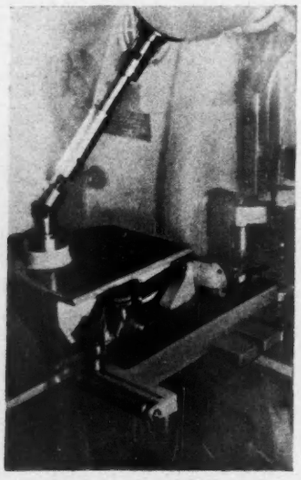
PRESS FEEDER

Cam Operated

AN automatic press feed attachment, made by George F. Clark, of West Drayton Middlesex, has a feed of up to 12 in and capacity for almost any width.

The drive to the unit is taken from the crankshaft of the press via a bevel gearbox. The shaft is telescopic and the box movable so the attachment can be quickly adjusted to suit any material or tool. The mounting is on an angle plate which bolts direct to the machine bed.

Two models are made, one with a feed up to 6 in and the other up to 12 in. The former is 20 in long and the latter 25 in. The respective overall widths are 24 and 30 in. The strip is fed at a height of 3 in above the press bed. The feed dial is graduated in divisions representing 0·004 in of feed. As one side is open, adjustment is merely a movement against the rear edge after the tool has been set. Up to 12 in width can be accommodated in the standard units. The feed time occupies 210° of the press cycle so the movement of the strip is slow and inertia kept down. The return of the cam is quick. *Catmur Machine Tool Corporation Limited, 103 Lancaster Road, Ladbroke Grove, London, W11.*



ROLL GRINDER

Work up to 32 in Diameter

THE TWA is a heavy duty machine for grinding rolls up to 32 in diameter and 192 in long.

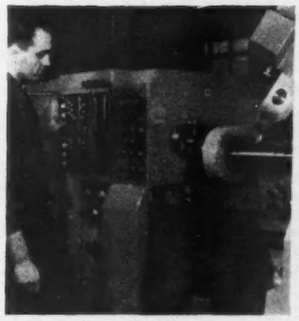
The bed is made in two sections, one for carrying the traversing wheelhead and the other for supporting the roll being ground. The two sections are bolted together along their entire length. Pressure lubrication is supplied to the slideways and is interlocked with the head traverse so that in the event of failure the traverse mechanism is stopped.

The grinding wheel head is fitted with a 40 h.p. variable speed motor driving a 36 in diameter wheel. Pressure switches in the oil pipeline prevent the wheel being started until the lubricating oil is circulating. The feed wheel is graduated to read in 0·000125 in. Quick power traverse is supplied under push button control. The wheel is fed to the work by hand to take up the load and then is traversed along the roll face. As the load falls, the drop in armature current energises the feed mechanism and advances the wheel. The regulator can be set progressively lower so that a very fine finish can be obtained.

The wheelhead base is mounted on the carriage at the front on trunnions and at the rear on the cam of the cambering mechanism which will produce both concave and convex forms. The workhead is driven by a 15 h.p. variable speed motor by V belts. The controls on the platform are also duplicated on the workhead for setting up the roll. Hand adjustment is also provided. All speed adjustments are carried out by push button and the speed is indicated on a tachometer. Journal rests with wide supports on the work bed are fitted with white metal lined pads on which the roll rotates. The rests are adjustable over a wide range of diameters. *The Churchill Machine Tool Company Limited, Broadheath, near Manchester.*

COPYING LATHE

With Programme Control



THE MAS semi-automatic copying lathe type SP31 is fitted with built-in programme control.

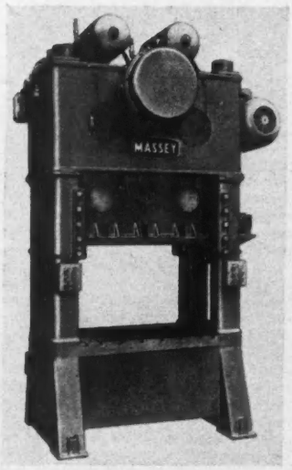
The machine is intended for turning complicated shapes either between centres or in a pneumatic chuck. Shafts up to 9$\frac{13}{16}$ in diameter and 39$\frac{1}{4}$ in long can be accommodated and the swing over the bed is 12$\frac{3}{4}$ in. Two copying carriages and a swivelling plunge-cut equipment can be fitted.

The programme is first set on a card and then contact pins are screwed into corresponding holes on the selecting plate on the headstock. The work cycle can contain up to 15 work phases for each copying carriage, and in each phase two operations may be selected. Thus with the two carriages in use up to 60 operations can be carried out in each cycle. The impulses for starting the preselected operations are given by stops on the 15 rings of the control drum, which can be set independently. The rotation of the drum is linked to the longitudinal movement of the carriage. The stops close contactors feeding the step relays and thence the electromagnetic control valves of the hydraulic system. Manual control is also possible by push button and there are separate buttons for plunge-cutting.

Automatic clamping equipment is fitted for shaft work between centres and a crane is available for loading and unloading workpieces. *Elgar Machine Tool Company Limited, 172-178 Victoria Road, Acton, London, W3.*

TRIMMING PRESS

Also Pre-forming and Finishing



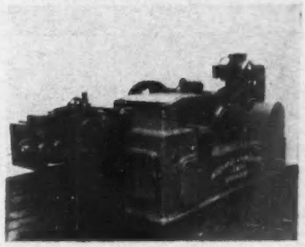
PRE-FORMING and finishing drop forgings, in addition to the usual trimming operations, are tasks within the scope of a new range of presses.

The sizes run from 100 tons to 1,000 tons and the areas of the work tables from 46 in by 30 in to a maximum of 84 in by 50 in. They are to be known as the "Wide Ram" range and the 100 ton version is illustrated.

Each press is provided with four one-piece cast steel pitmans to ensure the maximum resistance to tilting of the ram. All the bearings are generously proportioned and the clutch is of the direct air-operated friction type as used on the firm's other presses. The lubrication unit is automatically interlocked with the main press drive so that when the press is in operation adequate lubrication is provided for all parts. Alloy steel double helical gears provide the transmission. The frame, which comprises bedplate uprights and crown, is of the all-welded box construction for maximum strength. The whole frame structure is held together by four large diameter steel bolts shrunk into position. *B. and S. Massey Limited, Openshaw, Manchester.*

COLD FORGING MACHINE

Four Stations



THE horizontal transfer cold forging machine illustrated has four stations and a capacity for wire up to $\frac{1}{2}$ in diameter for heading, but will cut off wire up to $\frac{5}{8}$ in diameter.

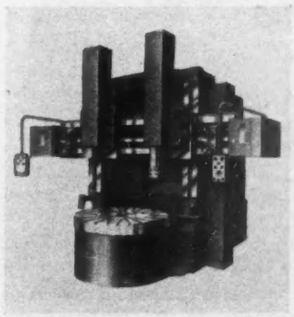
The machine runs at a speed of 100 to 120 blanks per minute and will produce components with a maximum shank length of 3 in and a cutoff length of 4$\frac{1}{2}$ in. The body is of rigid construction and the slide, operated by two connecting rods, holds accurate alignment. It has phosphor bronze liners on steel slips.

The wire is fed through straightening rolls to the feed rolls which are driven by friction clutch. The wire stop is adjustable from the operating position by a hand wheel. Cutoff and carry over to the first station is by an open cut knife with cam operated transfer finger. Subsequent transfers are carried out by fingers operated by rack and pinion. Dies are normally the built-up type and the punches are separately adjustable in all directions. Both die and punch ejectors are included.

The machine is driven by a motor through V belts to the flywheel and a clutch unit mounted on the high speed driving shaft. A double helical pinion drives the wheel on the main crankshaft. Either a slip ring motor or a variable speed one can be used. Safety features include microswitches fitted to the motions so that in the event of tool breakage the machine is stopped almost instantaneously. A 20 station four speed mechanical lubricator, with separate motor drive, supplies all the main bearings, surplus oil being drained back to the sump and recirculated after filtration. *Greenwood and Batley Limited, Albion Works, Leeds.*

VERTICAL BORER

Double Column



THE vertical boring and turning mill illustrated is representative of a new range which includes models which have tables of 5 ft, 6 ft, 7 ft and 8 ft diameter.

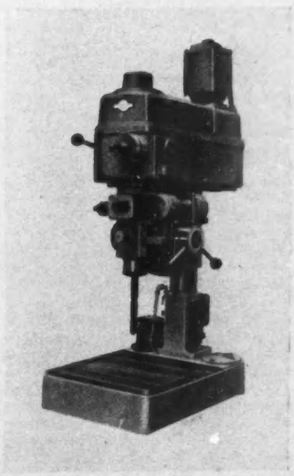
The machines are constructed sturdily and are reinforced to ensure rigidity during heavy cutting operations. An automatic pre-start lubrication system is built into the machine to ensure an adequate supply of oil to all moving parts, with the exception of the heads to which separate one-shot systems are fitted.

The table revolves on a specially designed tapered roller bearing which caters for all radial and axial thrust loads. Electromagnetic clutches are fitted in the main driving gearbox and feed boxes, facilitating push button preselection of a wide range of speeds to the table, coupled with push button selection of a wide range of feeds to all motions of the slides. Positive hydraulic clamping is provided to the cross slide, which comes into play automatically before and after operating the elevating mechanism.

The tool bars are rectangular in section, hydraulically balanced, and may be fed vertically, horizontally or at an angle. They will swivel to an angle of 30° either side of the vertical and have independent feed mechanisms. All movements of the machine units are controlled from the two pendant stations, one on each side. *George Richards and Company Limited, Broadheath, Altrincham, Cheshire.*

AUTO-CHANGE DRILL

With 58 Speeds



SPECIAL feature of the "78" drilling machine is that speeds can be selected without stopping the machine.

The standard model has a choice of 58 speeds over the range from 47 to 4,000 r.p.m., driven from a 1 h.p. motor. The drilling capacity in steel is $\frac{1}{2}$ in and the stroke is 5 in. The machine will drill to the centre of a circle of 18$\frac{1}{2}$ in diameter. Maximum clearance from nose to table is 18 in and the vertical adjustment of the head is 9$\frac{1}{2}$ in. The working area of the table is 13 in by 15 in.

An automatic power feed attachment can be fitted giving a choice of three feeds, selected by change gears. It is driven by worm and multitooth clutch plates. Manual feed is by sensitive rack and pinion. A return stop is fitted.

The drive is taken through variable pitch pulleys and V belt, with the control by a cranked handle at the front of the machine. A large diameter dial shows the speed selected. Auto manual control provides either continuous operation of the motor or will give automatic stopping and starting in phase with the spindle stroke. *Kerry's (Engineering) Company Limited, Warton Road, London, E15.*

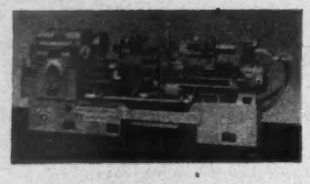
20 INCH LATHE

Automatic Screw Cutting

Now fitted to the type 8B2 sliding and surfacing lathe is automatic screwcutting equipment as well as profiling equipment.

The 8B2 has a capacity of 20 in by 68 in with a choice of 24 spindle speeds which can be preselected from a calibrated dial on the head according to the size of workpiece. A single lever makes the change when desired. The same lever also controls the selection of feeds and threads, only six changewheels being needed for the entire range of pitches. Separate levers select coarse or normal feeds.

The saddle is guided by the front offset V of the bed and both front and rear slideways are fitted with wear strips lubricated by pump. The square turret tool post can be indexed to 45° or 90° positions and locked by one movement of the lever. Hand control allows a total of 72 positions. Repetition tolerance is 0·0008 in at the end of a bar 6 in from the face of the turret.



The profiling slide is mounted at the rear of the extended cross-slide and moves permanently at 45° to the lathe axis. Operation is hydraulic with the stylus valve in the same unit. The model carrier is mounted on the base at the back of the lathe. A separate holder is available for templates. The front tool slide can be operated independently.

The automatic screwcutting equipment is hydraulically operated and can be brought into use immediately profiling is completed. Screws with 20 threads per in can be cut at 1,300 r.p.m., and 4 t.p.i. at 250 r.p.m. The capacity is the full centre distance of the lathe and the maximum depth of thread is 0·135 in. The lathe is set up by hand for the first pass after which the saddle is automatically returned and the leadscrew reengaged at the correct starting position. *John Lang and Sons Limited, Johnstone, Renfrewshire.*

SECTION ROLL

Horizontal Model

A new Besco all-steel section rolling machine is a horizontal pattern designed for the rapid formation of rings.

The standard version has 10 in diameter rollers which are adjustable to accommodate all standard sections within the range. Angles or T's up to 2½ in by 2½ in by ⅜ in; channels to 4 in by 2 in; flats on edge up to 2½ in by ½ in; rounds up to 1½ in diameter and squares up to 1⅜ in can be handled.

The twin main driving rollers are contained in a steel housing and supported by an overhead bracket to prevent deflection. The third adjustable pressure roller is mounted on a heavy steel slide in taper roller bearings. A pair of adjustable guide rollers is provided for supporting the work during rolling. The drive to the main rollers is from a 5 h.p. reversing motor through spur gearing to an enclosed worm gearbox; adjustment to the pressure rollers is by a separate 2 h.p. reversing motor and worm drive.

Both motors are fitted with magnetic brakes to give positive control. A central panel contains forward, reverse and stop push buttons. Reversing of the drive rollers is by a joystick. Normal supply is from 440V 3 phase 50 cycle mains. Removable panels enclose the main drive units. The main frame is fabricated from heavy steel sections and the rollers from spherical graphite iron. *F. J. Edwards Limited, 359-361 Euston Road, London, NW1.*

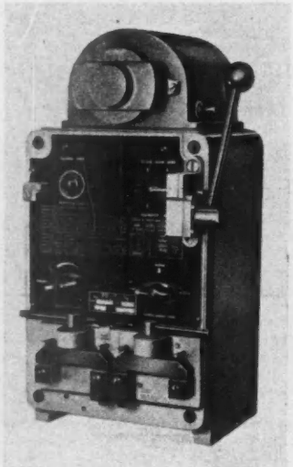
BUTT WELDER

For Band Tools

The "Ideal" butt welding machine has been developed primarily for making up band tools from coil stock.

The machine is automatic in operation once the welding data have been set from the chart. It can be operated by unskilled personnel. Even pressure is exerted by the eccentric levers giving good current flow. The moving jaw runs on precision ball bearing slideways to give precise and rapid upset to the butted ends of the band. The welding current, pressure, and jolting distance are all dial set, following which welding time and cutout are automatic. Annealing is under press button control to eliminate over-rapid temperature drop.

Standard equipment includes a built-on grinder for rapid weld dressing and a lever operated shear attachment to give an accurate 90° cut. Three models are made, with ratings of 2, 3, and 4 kVA, suitable for blades from ½ to ⅝ in; from ⅝ to 1 in; and from ⅞ to 1¼ in, respectively. Units are also available with or without grinders for building into



bandsaw machines. They will operate on 50 or 60 cycle supplies. *Startrite Machine Tool Company Limited, Darland Hall, Star Mill Lane, Chatham, Kent.*

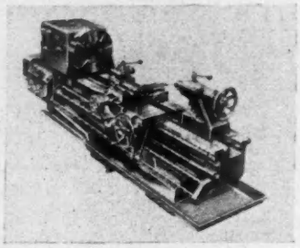
SCREWCUTTING LATHE

10½ in Centre Height

The DM10 lathe illustrated has 10½ in centre height, and is one of a series of redesigned machines with capacities from 6½ in to 14½ in.

It will swing 36 in diameter work in the gap, by 15½ in long, and 14½ in over the saddle. With a 10 ft bed the distance between centres is 5 ft 5 in and beds are available in standard lengths up to 24 ft which will admit 19 ft 5 in between centres.

The 12-speed gearbox has alternative ranges from 12 to 400 r.p.m. and from 18 to 600 r.p.m. The box is driven through a multiple clutch, and the constant speed driving pulley is mounted on ball and roller bearings on a sleeve to relieve the bearings of belt pull. An integral oil pump lubricates all bearings. The speeds are obtained by sliding gears operated by three levers at the front. The gearbox is totally enclosed. Twenty-eight Whitworth threads can be cut without altering the changewheels, and wheels are provided enabling BSW, BSF, Metric and Unified threads from 2 to



28 threads to the inch to be obtained.

The spindle is hollow and will take 3⅛ in diameter. It has a large flange to which chucks or face plate are bolted direct. Start and stop are remotely controlled. The spindle runs in phosphor bronze bearings, the thrust race being within the headstock. The saddle has quick motion hand traverse and the sliding feeds range from 14 to 196 cuts per in; the surfacing feeds are from 60 to 833 cuts per in. The lead screw is 2 in diameter with 2 t.p.i., and can be disengaged by a lever on the front of the gearbox. *D. Mitchell and Company Limited, Central Iron Works, Parson Street, Keighley, Yorkshire.*

AUTOMATIC CAPSTAN

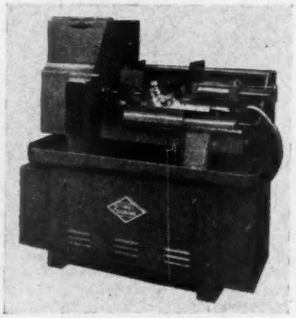
Plug-in Settings

The new Accuratool high speed precision capstan lathe is said to combine simplicity with rapid and consistent production.

Setting of the feed and speed values is by plug-in connections on the electrical control panel and the same method is used for the slide movements. The set-up can be quickly changed from continuous cycle for bar work to single cycle for chuck work and movements can be programmed to take place simultaneously, in sequence or in overlapping sequence.

The machine has a capacity for bar up to ⅝ in diameter and the centre height is 5½ in. Spindle bore is ⅝ in. The maximum stroke of the turret slide is 3 in and there are 16 spindle speeds in four overlapping ranges extending from 37 to 3,000 r.p.m. Power is supplied by a 1½ h.p. two speed motor.

The turret has six stations with dead length collets of the automatically opening and closing type. The control panel has two sets of sockets, one being



connected to the power and the other to solenoids controlling the machine movements, any of which can be actuated by plugging in the appropriate connection. On completion of the movement the signals transfer the power to the next step. By linking the sockets, movements can be kept in operation as long as desired. Time delays can be introduced at any step to provide tool dwell. *Dowding and Doll Limited, 346 Kensington High Street, London, W14.*

HONE

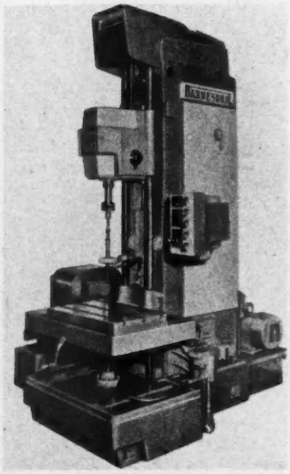
Electrical Expansion

Chief claims for the Barnes 244 hone are that it is compact and simple to operate and maintain.

The accuracy from bore to bore is consistent within 0·0002 in and the overall capacity is from ½ in to 6 in diameter bores. The large diameter applications are dependent on the amount of stock removal, the bore length and the material.

The machine incorporates an electric system of hone expansion that does not use valves or rectifiers. Expansion, collapse and compensation for stone wear are all electrically controlled. Alternatively the machine can be fitted with a pneumatic hone expansion system.

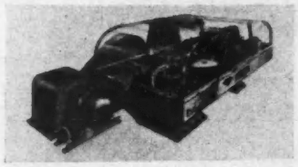
The stroke length is controlled by a dial mounted on the rear of the control panel arm and the four-speed transmission is controlled by a knob on the right side of the spindle head. Set up controls are protected by lock and key to prevent tampering once set. Power for the spindle drive is supplied by a 5 h.p. motor through a V-belt, and the



hydraulic reciprocation is powered by a separate 3 h.p. motor. *Gaston E. Marbaix Limited, Devonshire House, Vicarage Crescent, London, SW11.*

STRIP FORMER

Takes 12 in Blanks



THE latest addition to the Heenan range of wire and strip forming machines is designed for high speed production of large items.

The S3 has a capacity for a blank length of 12 in and a maximum width of 3 in using material up to $\frac{1}{16}$ in thick. Output speed is from 40 to 120 pieces per minute. The die area of the machine is 31 in long.

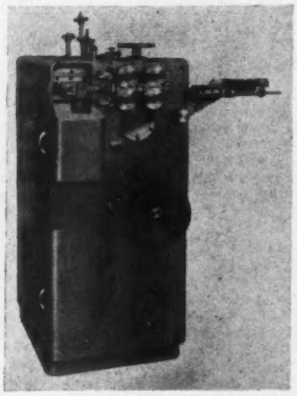
All four camshafts are intergeared and a flywheel is incorporated for smooth running. The flywheel can be disconnected either manually or automatically for quick braking. The controls can be linked electrically to ensure that the machine is automatically stopped under fault conditions.

The connecting linkages to the reciprocating feed are almost in a straight line from the operating crank disc, thus giving a straight-through pull to the strip. The stock is gripped by a pair of flat dies, one of which is mechanically operated by a cam. The feed slide can be positioned nearer to the ram when using a short feed thin strip, and a "throw out" allows the machine to cycle free during tool setting. A separate grip is provided for the return stroke on the feed side, operated by cams from the front shaft.

Room has been left on the bed plate for two press units as well as the standard cut-off. The horizontal press has a die length of 10 in and the entire assembly can be moved along the bed to obtain the best position. A load of 30 tons can be applied by each press. The machine can be supplied with one or two rams and in special cases a third can be fitted. The rams can be operated from the front or back. Each of the four slides is individually operated by a separate hardened steel cam capable of exerting a force of 6 tons on the component. *Heenan and Froude Limited, Worcester.*

COIL SPRING WINDER

Automatic Operation



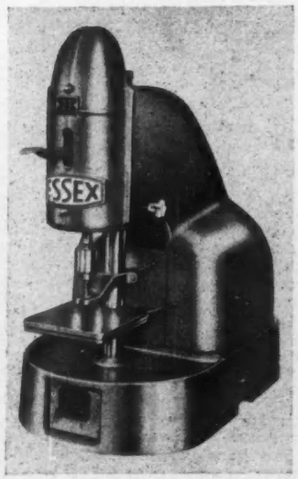
THE Torrington universal spring winder shown in the illustration is now available in this country.

Chief claims for the machine are that it has a high output with low maintenance costs. The model W11A is suitable for the automatic production of all types of spring for compression or extension, with or without closed ends, and with right or left handed coils. Cylindrical, single or double taper springs as well as simple rings can be formed. An attachment can be fitted to the basic machine that enables torsion springs with straight tails and with open or closed windings to be made.

In action the wire is drawn from the coil stand by two pairs of feed rollers and pushed into the coiling tool through guides. It is then formed into the requisite spring and cut-off after completion. When producing formed springs the coiling mandrel and the pitch tool are controlled by adjustable cams. The drive is steplessly adjustable by a handwheel, and a segment gear and crank plate allow infinitely variable adjustment of the wire length. All adjustments can be made while the machine is running. The control cams are easily exchanged and can be used on a variety of work. The pitch tool operates parallel to the spring axis. *Soag Machine Tools Limited, Juxon Street, London, SE11.*

TAPPING MACHINE

Bench Mounting



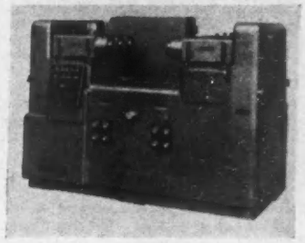
TWO recently introduced tapping machines, the Essex "22" and "23," are arranged for bench mounting.

The machines differ in capacity, the "22" covering from 14 to 4 BA and the "23" from 9 to 2 BA in steel. Other dimensions vary correspondingly. The "23" has a maximum spindle feed of 1 in and distance from table to chuck of $5\frac{1}{2}$ in; the clearance from spindle to column is $2\frac{1}{4}$ in. The table measures 6 in by 6 in and the overall height is 27 in, and the bench space required is 23 in by $14\frac{1}{2}$ in. Chuck capacity in both models is $\frac{1}{4}$ in.

Immediate reversal of the spindle occurs if the operator releases downward pressure on the operating lever. Either foot or hand control can be fitted. Motor and switchgear are built-in. There are three spindle speeds for both forward and reverse rotation, obtained by change speed cones mounted on the right hand side of the base. In the "23" the working speeds are 830, 1,180 and 1,680 r.p.m. Three-jaw chucks are fitted as standard and the table is adjustable for height. *Rockwell Machine Tool Company Limited, Welsh Harp, Edgware Road, London, NW2.*

FINE BORING MACHINE

Double Ended



TYPE FB2 is a double ended fine boring machine for a wide range of applications.

The table travel between bridges is 15 in and the table surface pad is 26 in by $8\frac{1}{4}$ in. The distance between the ridges is 28 in and the distance from table top to bridge top is 6 in. Bridge width is 21 in and the height of the boring spindle centre line is 4 in. Spindle speeds with the standard drive and slow idler are from 625 to 4,000 r.p.m. The table is fitted with a rapid approach speed of 23 ft per minute and fast feed range from $\frac{1}{2}$ in to 60 in per min. Slow range is from $\frac{1}{2}$ in to 50 in per min.

The machine is electro-hydraulically operated and can be tooled for single purpose operations with automatic quick acting fixtures and multiple tooling. Alternatively, it may be equipped as a fully universal machine. Standard operations that can be carried out include boring, facing, turning, and back facing. Feed rates are constant and cycle controls are simple. Up to three individual heads can be mounted on each bridge.

Adjustable cams or dogs fitted to the worktable are used to control the various cycles. A positive dead stop can be fitted for blind holes. The automatic cycle can be controlled by moving a throttle lever or direct from the push buttons. The throttle can also be used for slowing down or stopping the table anywhere during the working cycle. A brake brings the spindle rapidly to rest before the reverse comes into action. The slideways are all automatically pressure lubricated using a grooved manifold system. *Stuart Davis Limited, Much Park Street, Coventry.*

BELT GRINDER

Totally Enclosed

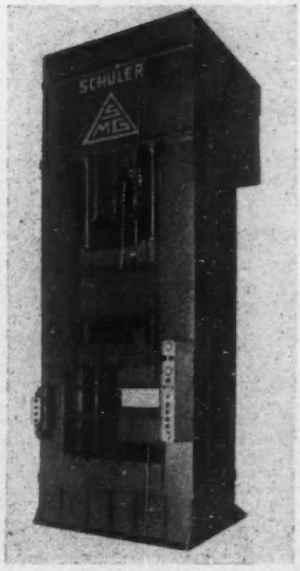
THE Diamant 225 is a floor mounting belt grinder which is totally enclosed.

The machine is small and compact and it is claimed that it can do work equal to many larger ones. Power is supplied by a 2·5 h.p. motor running at 2,800 r.p.m. The belt is 7 ft 4 in long and the maximum width that can be accommodated is 3 in. The rubber contact discs are 10 in by 1 in, 2 in or 3 in. The height of the working position above ground is 36 in, while the machine requires only 20 in by 33 in of floor space. It weighs 285 lb.

A special feature is that when the side cover is opened (there is only a single locking handle) the belt is automatically slackened off for quick changing. There is a drawer to collect the grinding dust so that it does not fly about the room. The platen can be covered when not in use. All parts are readily accessible for easy maintenance and the exterior design has been chosen to give a smooth appearance. It is claimed that the machine is robustly built, practical and versatile; it is fitted with the latest design of belt driving wheel. It is also claimed that being designed for the purpose it is economical to run. It is intended for dry belt operation. *Addison Tool Company Limited, Addison House, 28 Marshalsea Road, London, SE1.*

DRAW PRESS

Double or Treble Acting



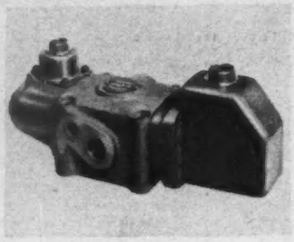
HYDRAULICALLY operated, the Schuler drawing press can be used as a single, double or treble acting machine.

Power is supplied by an axial piston pump with a constant power device to control delivery. Reversing is obtained by tilting the swash plate. The frame design is such that presses of different capacity can be built from standard hydraulic parts.

In double or treble action the upper sheet holder ram moves below the main ram so that any tilt in the sheet holes is not transmitted to the drawing ram. On the standard machine the sheet holder pressure is generated through the use of four differential pistons by the main ram in such a way that only 20 per cent of the sheet holder pressure is subtracted from the main ram pressure. Each of the four cylinders is independently controlled. By connecting the cylinders to the main pressure circuit the press can be operated as a single acting machine. *Pearson Panke Limited, 1-3 Hale Grove Gardens, London, NW7.*

SERVO VALVE

Electro-Hydraulic Operation



THE servo valve illustrated is designed for the control of hydraulic systems by electronics.

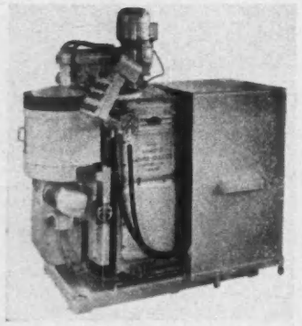
The valve consists of a rotary torque motor driving a pilot valve which provides one stage of hydraulic amplification to control the position of the second stage piston. The first stage consists of a nominally zero-lapped three-way valve, which is driven against springs by the motor. Balanced windings are fitted in the motor, which may be of either high or low impedance as required. An inductive rotary pick-up is also driven by the motor and is used to close a feedback loop around the pilot valve.

The second stage consists of a conventional piston valve which may be fitted with either a 4 or 5-way piston. Zero, under- and over-lapped pistons are available. A feedback loop makes the position proportional to the input signal, an inductive pick-up of the rotary type being used for this purpose. The servo control unit consists of a torque motor amplifier, two error amplifiers, two phase-sensitive rectifiers, and a.c. and d.c. power supplies. Carrier frequencies in the range from 400 cycles upwards may be used to energise the pick-offs.

Two sizes of the valve are being made, one for a flow of 25 to 30 g.p.m. for a pressure drop of 1,000 lb per sq. in, and the other with a flow rate of 100 g.p.m. for the same drop. The maximum power to the load is 40 h.p. and the maximum servo pressure 3,000 lb per sq. in. Step response time for full deflection is less than 8 milli-seconds. *Keelavite Hydraulics Limited, Allesley, Coventry.*

AUTOMATIC SURFACE GRINDER

Rotary Table



THE machine illustrated is a rotary table surface grinder type ASG1 with a fully automatic cycle.

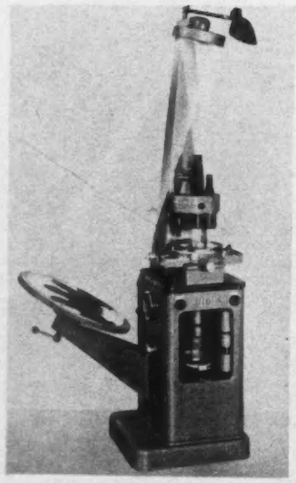
The capacity is for workpieces up to 15 in diameter, with both flushed and recessed annular faces. The clearance between the wheel and table is 12½ in. Drive to the wheel and table rotation are electric, all the remainder of the motions being hydraulically operated and electrically controlled. Fitting a cam can alter the cycle to cater for a wide range of stock removal, and flow control valves fitted in the hydraulic circuit can alter the cycle times.

The machine incorporates a 3 h.p. motor for wheels up to 6 in diameter and uses the Hydrocol grinding spindle assembly. The table is driven from a constant speed motor through pick-off gears to give a speed range of 25 to 100 r.p.m. Diamond sizing permits repetitive sizing to 0·0005 in and there is automatic wheel dressing between roughing and finishing cuts. Hydraulic power is used for the rise and fall of the knee, cutting feed and return of the cam slide, wheel wear compensation and rise and fall of the wheel trueing diamond. Push buttons are provided for manual setting and adjustment.

The head of the machine has a cross traverse of 9 in and the area enclosed by the splash guards is 18½ in by 19½ in. The vane hydraulic pump is driven by a 2 h.p. motor and the coolant pump by a ¼ h.p. one. *Abwood Machine Tools Limited, Princes Road, Dartford, Kent.*

CONTOUR PROJECTOR

25½ in Screen



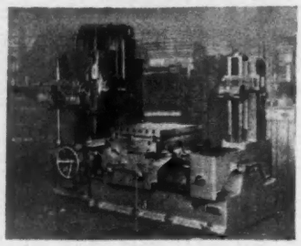
THE GP650 is a large contour projector with a screen of 25½ in diameter.

The instrument represents a combination of projector and measuring machine. The enlarged image of the workpiece is reproduced on a lateral screen, and precise length and angular measurements are carried out by means of a rigid measuring stage, controlled by micrometer screws. Either episcope or diascope working is possible or both types can be combined. The projector has an intermediate image system into which graticules and master samples can be inserted for comparison.

Four objectives give magnifications of ×10, ×20, ×50 and ×100. The maximum field of view is 2·56 in diameter. The objectives are made parfocal to avoid having to refocus on changing the magnification. The total longitudinal measuring range is 6 in and the cross travel is 2·35 in. Floor space required is 80 in by 80 in and the overall height is 110 in. The range of accessories includes centre cradle, gear testing device, reticule turret and drawing holders. Heavy workpieces can be accommodated. *E. Leitz (Instruments) Limited, 20 Mortimer Street, London, W1.*

HORIZONTAL BORER

Hydraulic Tool Clamp



A SPECIAL feature of the 451 P Optimetric horizontal boring machine is the inclusion of a hydraulic clamp and release for the tool.

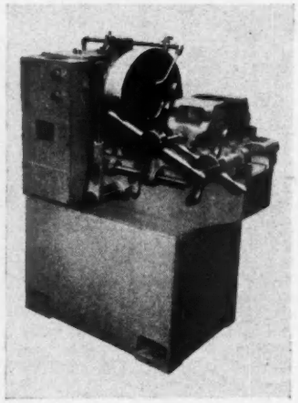
The machine is a general purpose one for toolroom or workshop and has a cellular bed for strength. A channel in the bed houses the longitudinal screw and shaft together with their associated mechanisims, running submerged in oil. The centre guide of the saddle also runs in this channel. Unit construction is used in the machine, each unit being fitted with its own independent lubrication system.

The new hydraulic tool release and clamping system is operated by a rotary switch fitted in the main control pendant. In order to ensure accurate and constant effort when holding the non-stick mandrels in the spindle nose, the central drawbar is pulled into position by a spring housed in the end of the main spindle, the bayonet catch enabling the mandrel to be withdrawn easily and quickly. The spring is overcome by applying hydraulic pressure to a cylinder attached to the end of the spindle. This mechanism will fail safe and enables rapid and accurate tool changing.

The machine has a spindle 3 in diameter and the facing chuck will face up to 24 in diameter. The maximum distance from the facing slide to the boring stay is 4 ft and the revolving table is 2 ft 6 in square. Power is supplied by a 7½ h.p. motor allowing a total of 27 speeds. The Optimetric setting system allows setting of the spindle slide and boring stay to 0·001 in to a limit of error of ± 0·00025 in. *H. W. Kearns and Company Limited, Broadheath, nr. Manchester.*

SCREWING MACHINE

6 in Capacity



A NEW addition to the range of screwing machines is the 6 in capacity universal type illustrated.

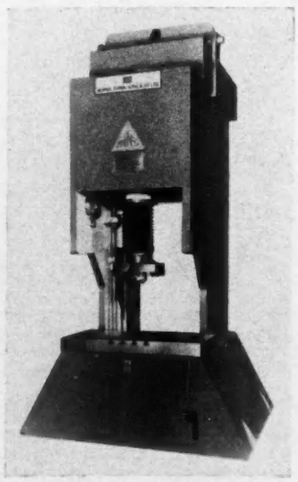
The machine is arranged for driving from a constant speed motor and is mounted on a cast iron cabinet which forms the suds tank and trough for the swarf. The machine is fitted with a cam type radial diehead which can be opened and closed by a bow fork and lever while the machine is running. The saddle is mounted on square slideways. The vice is of the open jaw self-centring type, and jaws are supplied in sets of two up to 1 in diameter and sets of four for the larger sizes.

The capacity range for pipes is from ¼ in to 6 in diameter and for bolts from 1 in to 3 in. Maximum travel of the carriage is 9 in and maximum length of thread on pipes of over 4 in bore also 9 in. Four spindle speeds cover the range from 4 to 26 r.p.m. The motor is rated at 3 h.p., 950 r.p.m.

The motor is flange mounted and drives through a flexible coupling. Spindle speeds are changed by change wheels running in an oil bath. The final drive to the main spindle is by a case hardened and ground nickel steel worm and a centrifugally cast phosphor bronze worm wheel. *Joshua Heap and Company Limited, Oldham Road Engineers Tool Works, Aston-under-Lyne.*

DOWN-STROKE PRESS

Single or Automatic



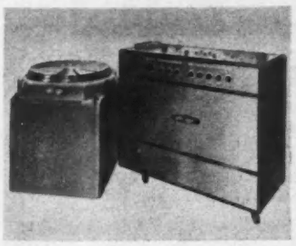
A NEW Barnes press has a rated capacity of 100 tons with a maximum operating pressure of 3,000 lb per sq. in.

The bed area is 54 in by 26 in and the overall height is 8 ft 9 in. The depth from front to back is 6 ft 6 in and the overall width is 4 ft 6 in. The height to the top of the bolster from ground level is 34½ in. The 4 in thick bolster is equipped with diagonal T slots and the centre hole, which is 7 in in diameter, is fitted with a removable ring. The maximum admission between side plates is 36 in.

With a down ram speed of 35 in per minute and an up stroke rate of 50 in per minute, the independent pressure control valves that are available in the approach and return strokes enable a predetermined stripping pressure to be used if desired. The automatic stroking device allows single or repeat stroking to be selected at will. The stroking is variable from 1½ in to 12 in. The hydraulic pump is a monoradial type made by Andrew Fraser and is driven by a 7½ h.p. motor. *George Cohen Sons and Company Limited, Wood Lane, London, W12.*

DIVIDING ENGINE

Accurate to 2 seconds



It is claimed for the new Sperry-Orcutt dividing engine that it can be positioned to within 2 seconds of arc and has a repetition accuracy of $\pm \frac{1}{4}$ second.

The machine has a platen 31 in diameter capable of carrying loads up to 1,500 lb. Positional control is obtained from information coded on standard teleprinter perforated tape or from a set of manual dials. The accuracy is the same in both cases. Accuracy is not affected by changes in room temperature nor by fluctuations in mains supply. It will operate from a 240V, 1 phase supply.

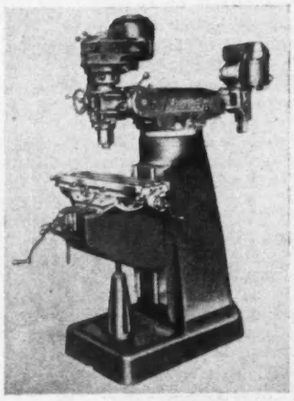
The equipment uses standard 5-hole tape and a modified Creed printer for punching. The information is recorded in degrees, minutes, and seconds down to 0·1 sec so that eight rows of holes are needed to define an angle. For prototype work or one-off jobs the platen can be controlled by setting up the angle on the dials.

Four modes of operation are available. The platen may be rotated continuously at 2 r.p.m. so that the workpiece can be set up and clocked concentric with the axis. Second, the dividing engine may be indexed for information set on the dials. Third, single shot indexing can be obtained from tape; and fourth, automatic indexing can also be obtained from tape. In this last case a signal from some external source is needed to initiate an index movement.

There are three models available: one for use on the table of a standard machine; one as a complete special purpose tool with vertical and horizontal boring heads; and one as a fully automatic recording gear tooth pitch checking instrument. *Gear Grinding Company Limited, Shirley, Solihull, Warwickshire.*

TURRET MILL

Inclinable Head



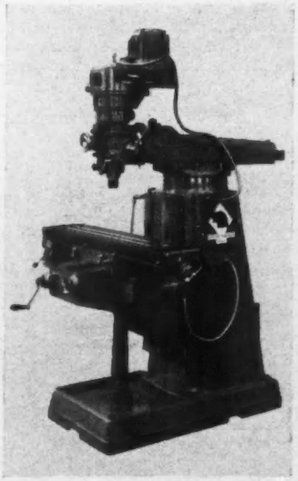
Now being made in this country are the Bridgeport milling machines, of which the model BRJ is illustrated.

The ram and turret design of the machine permit the milling head to be set angularly in both planes without loss of rigidity. Angles in all planes are set through worm gear controls. The ram, sliding in V's, permits movement of the milling head over the table without rechecking the squareness of the spindle. In and out movement of the ram is by rack and pinion requiring the minimum of effort. The rear end of the ram has a swivel adaptor for mounting other attachments for very high speed milling or shaping.

Longitudinal travel is 30 in and cross travel 12 in. The vertical travel of the knee is 16 in. Maximum distance of spindle to the table is 18½ in and spindle to column is 25 in. The table measures 42 in by 9 in. The J type head is driven by a 1 h.p. motor with speeds ranging from 67 to 2,300 r.p.m. Power feeds are 0·0015, 0·003 and 0·006 in per revolution; fast and slow manual feeds are also provided. The quill travel is 5 in and a micrometer stop is graduated in 0·001 in. A wide range of attachments includes hydraulic duplicating equipment and optical and micrometer measuring units. *Adcock and Shipley Limited, Ash Street, Leicester.*

VERTICAL MILL

Swivelling Turret



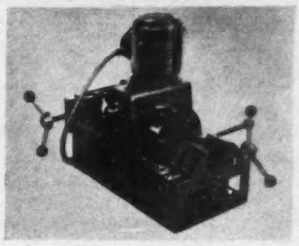
Recently introduced is the Balding Beaver swivelling turret milling machine type VBRP.

The machine has three rates of autopower down feed with spindle travel of 5 in. Four sizes are made with tables measuring from 32 in by 10 in to 48 in by 10 in. Longitudinal movements are from 12 in to 28 in. Cross table traverse is 12 in and vertical table movement is 19 in. Power feeds are from ½ in to 4½ in, or from 1 in to 9 in per minute. The spindle speed range is from 80 to 3,000 r.p.m. and the spindle line turns through 180° in the longitudinal plane and 90° in the transverse plane. Power is supplied by a 1 h.p. motor.

The drive is by V belt to a four step idler pulley and then through helical gearing. An adjustable depth stop is fitted on the spindle. Fine feed hand is by handwheel with micrometer. The ram movement is actuated by rack and pinion. Easily read micrometer dials are fitted to the table controls. Power traverse is supplied by a 0·1 h.p. motor and gearbox, using pick-off gears. *Stedall Machine Tool Company, 192-208 Pentonville Road, Kings Cross, London, N1.*

THREAD CUTTING MACHINE

With Hollow Spindle



Now available in this country are the F.o.B. thread cutting machines designed for bench or pedestal mounting.

There are three machines in the range: the 2UV has a two-speed motor with speeds of 17 or 34 r.p.m. at the diehead, with the optional alternative speeds of 29 and 58 r.p.m.; the 2MV which has a single speed motor and a gearbox giving a choice of 14 or 24 r.p.m. Alternatively, this can be fitted with a two speed motor allowing a choice of four speeds of 14, 22, 29 and 45 r.p.m. Both these machines have a capacity for pipes from ¼ in to 2 in diameter and for bolts from ¼ in to 1½ in diameter and will cut threads from 12 to 52 mm.

The third machine, the 4MV, has a two-speed motor and gearbox giving speeds of 14, 22, 29 and 44 r.p.m., the capacity being tubes up to 4 in and bolts up to 2 in diameter. All three machines have hollow spindles allowing threads of any length to be cut and are fitted with self-opening dieheads for tangential chasers. There is a built-in cooling system. A pipe cutter is fitted as standard equipment which allows tubes after threading has been completed to be released from the vice, passed through the spindle and held in a chuck at the rear of the headstock, which is then used to rotate the pipe. The pipe is supported on two rollers, while a third roller makes the actual cut. This last is operated by a hand wheel. Driving motors are normally for operation on 440V supplies 3 phase 50 cycles. A fixture is available for grinding the chasers in their own holders on a standard surface grinder. *Newage Machine Tools Limited, 98-100 Croydon Road, London, SE20.*

DIAL GAUGE

High Sensitivity

The illustration shows the mechanism of the new super sensitive John Bull dial gauge.

These instruments have a case made of a rigid casting into which are inserted hardened and ground stainless steel stem bushes carrying the rack spindle. The movement plates carry inserted brass bearing bushes which are interchangeable, and the pinions are hardened and lapped throughout to provide a very high degree of sensitivity and accuracy.

The rack return spring lever is specially formed to provide constant tension throughout the travel of the indicator and is compensated against the build-up of the return spring. This lever runs in a grooved guide roller to further minimise friction, while the gears themselves are of special instrument brass. The indicator hand (which is not shown in the illustration) is balanced to eliminate drag.

The gauges are available in four dial sizes: 1½ in, 2 in, 3 in and 4 in, and with all recognised graduations. They are guaranteed, and conform to BS 907. *British Indicators (Sales) Limited, Sutton Road, St. Albans, Hertfordshire.*

JIG BORER

Three Control Systems

Two forms of positional control can be fitted to the model 1520 vertical jig borer illustrated.

The basic machine has a work table 15 in by 20¾ in with 10½ in traverse and 15½ in longitudinal movement. Twelve spindle speeds cover the range from 67 to 3,000 r.p.m. There is a choice of three coordinate hand setting systems, all accurate to 0·00005 in. These are the Newall patented roller measuring system; precision screw and vernier dial; and an optical setting system.

In addition the same machine can be fitted with Spacematic control using the Airmec system to give rapid settings to an accuracy of 0·0005 in.

Model 1520CC incorporates the AEI Helixyn system of continuous numerical control of three movements. This system comprises capacitative non-contact elements acting as a feedback servo system. The basic unit of length is 0·0001 in, which is also the limit of accuracy. *Newall Group Sales Limited, Old Fletton, Peterborough.*

Factory Designed for Clean Production

Inverted "umbrella" shell roofs and slab floors that are jacked up from the casting bay at ground level are two features of a factory now being built.

THE first major building structure in the programme for development at Bedford for Texas Instruments Limited, makers of transistors, will be approximately 430 ft square. It will comprise a three-storey office block 270 ft long by 50 ft wide, surrounded on all sides by the manufacturing area, which has a continuous services space below the whole of the production floor. Two-storey links crossing the inner courts will provide access between the offices and manufacturing areas. The present contract, scheduled to take 12 months, covers the office block and two-thirds of the manufacturing area, and is due for completion later this summer.

Requirements

The main building is designed for the manufacture of semi-conductor devices, including transistors, and the production process requires a very high degree of cleanliness, together with rigid control of air temperature and humidity. To provide these conditions, an extensive air-conditioning system is being installed; it will comprise a main fresh-air plant and 30 re-circulating plants, all served by a 350 h.p. refrigerating compressor.

Piped services required for the manufacturing process include compressed air, towns gas, hydrogen, nitrogen, argon, demineralised water, marine water and hot water. Process drainage is by a special system of chemical effluent drains. All these services will be housed in the services space below the production floor.

The complexity of these requirements is increased by the need for complete flexibility: production lines are expected to be revised frequently, but, at the same time, the vital air-conditions have to be maintained and all services must be immediately available everywhere.

Roof Shells

The layout evolved for the manufacturing area calls for roof form made up of hyperbolic paraboloid umbrella units 48 ft square, rising from 9 ft at the springing to about 18 ft at the edges. The 18 ft high side walls will be of aluminium window-walling for their full height, with external brick towers at intervals along the length of the building; these towers will be about 16 ft wide and will project 9 ft from the wall. They will function as service shafts between the manufacturing area and the continuous 10 ft high services space below it. All piped services will be fed through the floor on a 10 ft module. Thus the working area will be clean, simple and light with all services hidden out of sight, though directly available.

The hyperbolic paraboloid roof shells have, by virtue of their double curvature, great stiffness and an inherent resistance to buckling; although they each cantilever 34 ft on the diagonal, they have been made only 2½ in thick, sufficient only to contain the necessary reinforcement.

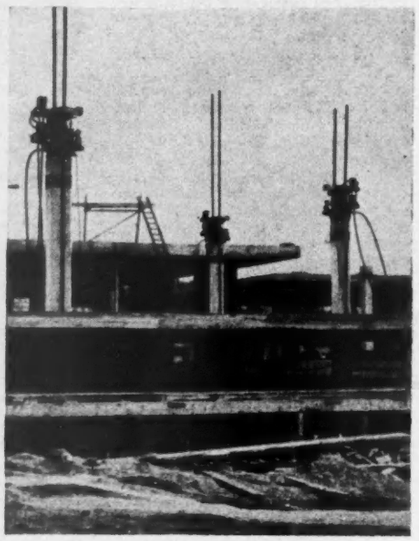
Each shell stands free, entirely independent of its neighbour, with a 3 ft 6 in gap between them; this gap can be used for continuous roof sky-lights later, if desired. Edge thickenings are provided to the perimeter of each shell to take the tension forces, and four radial thickenings are provided down the lines of maximum slope to take the compression forces. Column head thickenings 8 ft square are provided to give continuity with the columns and assistance to the compression ribs in taking the secondary cantilever moments.

In addition to loads from roof insulation and show, provision is made in the shell design for a continuous edge load of 100 lb per ft run which will arise from fluorescent light fittings, cable trays, sprinkler mains, and air-conditioning ducts. The maximum deflections and tilt likely to arise from out-of-balance loadings of snow and services were determined from a one-sixth scale model that was constructed and tested by the Cement and Concrete Association.

Floor Slabs

All suspended slabs for the manufacturing area and office wing are being constructed by the lift-slab technique. With this system the slabs are designed as flat plates, cast at ground level, and subsequently lifted one at a time to their required levels. An exceedingly high speed of construction is thereby obtained.

The procedure is as follows:—For the office wing, universal-section steel stanchions with rigid base connections are first erected so that they stand free to the full three-storey height of the building, as vertical cantilevers. After the ground floor slab has been cast, all suspended slabs are then cast, one on top of the other, with a separating building paper between. The size of slab cast in each pour is about 80 ft by 50 ft, extending over twelve stanchions. Hydraulic jacks are fitted on the tops of each of the twelve stanchions, and connected to welded steel collars previously cast into the roof slab. The total weight of each lift is of the order of 250 tons. The slab is then jacked up to its final position, and supporting steel shear-plates are welded to the stanchions underneath the slab. Next the second floor slab is lifted, and finally the first floor slab.



A suspended slab being lifted, with the jacks in position at the top of every column.

To obtain a uniform lift, all the jacks are connected to a common pump, but the operator is able to control the jacks individually.

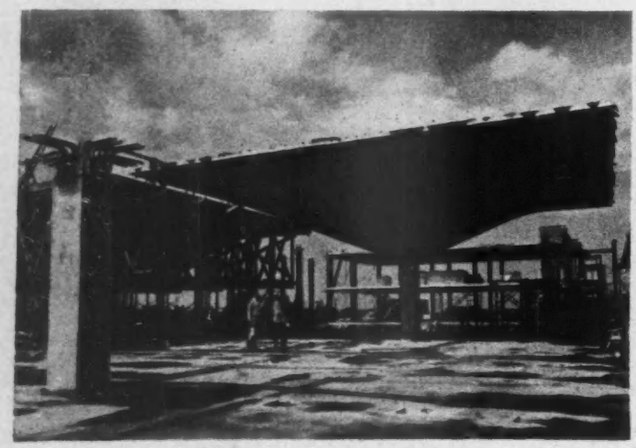
For the manufacturing area it was found cheaper to use RC columns. This necessitated the development of a steel helmet-box to which the shear-plates are welded. The helmet-boxes are fitted on the inside with steel shoulder-straps which take the load off the edge of the concrete column and transfer it back to the central core. The slabs at Manton Lane are being lifted by British Lift Slab Limited.

Foundations

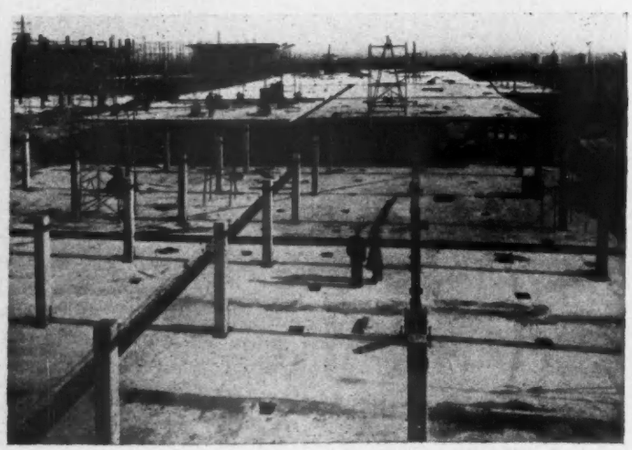
The building is founded on independent column bases bearing on the boulder clay at a maximum working pressure of 4 tons per sq. ft. A sub-floor drainage system has been provided to cope with capillary water flow from the clay. No sub-floor damp-proof membrane has been provided.

The architects for the project have been the United States firm of O'Neil Ford and Richard Colley, of Texas. The consulting engineers are Oscar Faber and Partners of St. Albans and the contractors Tarmac Civil Engineering Limited of Park Street, London, W1.

The " inverted umbrella " roofing shells over the manufacturing area.



Floor slabs in the manufacturing area, before and after lifting.



The World's Largest Hydro Power Site?

The Fraser river (in British Columbia, Canada) has more power potential than both the Canadian Columbia and the Peace river combined and could produce power at tidewater at less than half the average of those two rivers. This claim was made by Mr. R. E. Potter, a consulting engineer of Victoria, B.C., while addressing the 74th annual meeting of the Institute of Canada in Winnipeg last month.

He went on to say that the Fraser has the site for the largest power plant in the world. This plant could turn out power comparable to the "lowest cost power in the world." It would remove the flood menace of the Fraser river. It would improve navigation to such an extent that the river could be used for an additional 30 miles and probably solve the silting problem of the river. Dredges now remove the silt in the lower Fraser at a cost of over a $1 million per year.

Mr. Potter continued by stating that the "reason why the river was not being considered was because of the salmon involved . . ."

Three limited projects, however, had been considered by the Fraser River Board. The schemes cover both power and flood control of the river, and the flood control for all three schemes was the same: a minimum of 9·23 million acre-feet. The cost of all these schemes is put at $2 billion, including transformer and transmission costs amounting to more than $40 per kW of installed capacity and more than $60 per kW of assured energy production. In each of the schemes the "nominal prime capability" is of the order of 5,100 MW and the usable storage ranges between 16½ million acre-feet and 27 million acre-feet. Without transmission charges, the "cost per installed h.p. becomes $175."

Within the schemes the largest single project was the Moran dam, which would raise the river level by more than 720 ft. The generator installation proposed was 3,600 MW. This particular project could be developed without detriment to the fishing industry. It was believed that an effective method of guiding the fish electrically could be installed, but the problem of taking the adult fish over the dam by mechanical means seemed the most feasible. Fish ladders miles in length and on steep canyon walls were out of the question, but short ladders mounted on cars, moving up and down the face of the dam, were quite practical. Nearly 750,000 fish might have to be handled in a 24 hour period.

DSIR's Road Safety Track at Crowthorne

The road safety track for the Road Research Laboratory of the Department of Scientific and Industrial Research, being built at Crowthorne in Berkshire, is expected to be finished this month (June).

The track has been designed for work on traffic and safety measures, with particular emphasis on vehicle behaviour, including high speed studies up to 80 m.p.h. It is in the form of a figure of eight, with a total length of 3 miles, which will contain a number of different test sections. Several types of road surface have been laid.

Light and dark coloured surfaces will be used to study the contribution they make towards the visibility procured by headlights, and the effects of different street lighting on the visibility of vehicles, cyclists and pedestrians. High speed skidding and braking studies will be conducted on a banked bend that can be flooded from a built-in watering system.

Equipment is also to be tried out for vehicle detection and guidance, using sub-surface cables that carry radio-frequency and audio-frequency supplies respectively. The object is to investigate methods that will reduce fog and dazzle hazards.

In the centre of the track an extensive paved area has been laid out that will be used for the investigation of possible layouts for road junctions. The experiments will include trials with traffic signals, new types of traffic detectors and control systems for isolated junctions and for combinations of junctions. Weaving patterns of traffic will also be studied.

Tests will also be undertaken to measure the movement of vehicles being driven badly or while they are in a faulty condition.

The site is roughly 253 acres in extent and by 1964 will house the whole of the Road Research Laboratory, now occupying the two separate centres at Harmondsworth, Middlesex, and Langley, Buckinghamshire.

Aluminium Towers on 345 kV Power Line

Four aluminium guyed transmission towers have been erected on the 345 kV line between the Chute-des-Passes power station and the Isle Maligne, Quebec. The towers, used in one of the circuits just north of the Isle Maligne terminal, were designed by the Aluminium Company of Canada Limited and referred to in a paper by Mr. H. B. White, of Alcan, in a paper read before the Engineering Institute of Canada, when the Institute held its 74th annual meeting at Winnipeg last month.

Each of the guyed towers consisted of a cross-arm and two aluminium latticed masts in a V arrangement resting on a single footing. The speaker said that "a complete 76 ft tower, excluding the four guys, contained 2,400 lb of structural aluminium alloy shapes, as compared to about 12,500 lb of galvanised steel in comparable conventional towers used in the rest of the line."

Mr. White added that the work done in the development and construction of these towers has proved so satisfactory it was possible that they would be adopted as standards, for certain types of work, throughout the world.

Estuary Pipeline for Treated Effluents

A mile of 18 in diameter steel pipeline has been laid in the Usk estuary to take away treated effluent from the Newport factory of Monsanto Chemicals Limited. It is a replacement for an old cast iron outfall that was of insufficient size to handle the expected growth in the load to be carried.

In a prepared working site the pipes, of hot finished seamless steel with a diameter of 18 in and a wall thickness of ½ in, were electrically welded into two lengths of 2,440 ft. Welding was by the "stove-pipe" method and a full gamma-ray check was made on all welds. Each section was pressure air tested to 100 lb per sq. in.

The pipes are protected externally by a bituminous solution reinforced with a woven glass sheathing covered by a ½ in layer of reinforced concrete. The weight of each section (in air) was 240 tons. After welding, the inside of the pipe was lined with a coal tar epoxy resin having a dry film thickness of 15 mils. As it was impossible to coat the tie-in joint internally after welding, stabilised stainless steel sleeves, 18 in long, were welded to the sections before making the final joint.

The location of the pipelines was decided only after work on a model of the estuary at the Hydraulics Research Station at Wallingford and the discharge point has been located at a point below the lowest predicted tide level. The currents in the channel run at right-angles to the pipeline, which has therefore been buried throughout its length. To do this a trench was "trawled" across the river by pulling a plough through the bed; the trench was 3 ft deep and approximately 8 ft across at the top. The drawbar pull required was 100 tons.

To ease the task of pulling the pipeline into the trench, buoys were attached at regular intervals to reduce the weight in water from 40 to 20 lb per ft. With the pipeline in position, it was filled with water to accelerate settling into the trench, where the action of the tide will eventually bury it. The discharge end of the pipe is anchored and the whole of the pipeline is cathodically protected.

Monsanto's contractors for the work were Land and Marine Contractors Limited of Bromborough, Cheshire, who, besides constructing and laying the pipeline, also made the hydrographic survey of the estuary before work began.

Tunnelling in Sand

Horizontal and vertical partitioning in the face of a tunnel shield makes it easier to drive through loose sand. The idea has been worked out on a Russian site and a prototype shield has shown some substantial cuts in tunnelling time. Each of the cells into which the shield is divided is said to contain a "band of horizontal platforms" which can be moved forward separately by jacks.

Vibrating picks mounted on the cutting edges have also been found to speed the rate of advancing.

Eight Conditions for High Buildings

Eight conditions will have to be satisfied by buildings before they receive approval by the London County Council for construction within the council's area. General Government policy is to examine each high building project separately on the basis of the individual merits of each project, but the LCC will apply the following eight tests.

(1) Would the building disrupt the pattern of existing development or obtrude on the skyline to the detriment of existing architectural groups?

(2) Would it have a positive visual or civic significance?

(3) Would the site be large enough to permit a base of lower buildings or open space?

(4) Would it overshadow adjoining areas and stifle good development there?

(5) Would it be better than a lower building and relate satisfactorily to other buildings nearby?

(6) Would its design and materials be of good quality?

(7) Would it relate satisfactorily to open spaces and the Thames?

(8) Would its illumination at night detract from London's night scene?

It is difficult to explain entirely the crop of high buildings that is springing up everywhere. In London itself the high cost of land is the significant factor; not only is the ground area of the structure smaller with the tall building, but the area is more efficiently utilised, for rooms can be distributed around a central lift shaft without space-wasting corridors. Moreover, the mere cost of land is not the sole factor. The cost of erection can also be reduced by building high, the widespread use of tower and climbing cranes contributing much in this respect.

But these two facts still do not explain the high buildings that are going up in every more-than-medium sized city in all six continents. High land costs cannot enter into the problem when the city outskirts—where several acres can be had for a few hundred pounds—are less than two miles away, and the city's road system is used to less than half its capacity.

Civic—and commercial—pride seems to find an outlet by building high.

Bonus Schemes are Not What They Seem

A bonus scheme for the operatives can be the source of definite disadvantages to the firm. What may be wanted is resolute and vigorous management and not the shared responsibility of bonus systems.

By R. J. B. Stein, B.A. (Cantab)

THE raising of the level of industrial productivity in this country is a major problem, and one of the keys to its solution lies in the effective use of incentives. It is commonly thought that the more personal the incentive, the more effective it is.

A system of " payment by results " might be expected to be more effective than, say, a profit sharing scheme. Such a generalisation is unwarranted, as is shown by an examination of the so-called " bonus scheme " in the engineering industry.

In mass production industries a personal incentive is impossible, for the operative can only work at the " speed of the belt "; in such cases group incentives, based on the productivity of the various sections of the factory, must be used. In jobbing industries, in which the operative performs various tasks within the same field as each particular order requires, the bonus system is a very common form of incentive, and a substantial proportion of the engineering industry uses a bonus system in some form or other.

HOW THEY WORK

A simple bonus scheme might work in this way. A designer first makes a drawing of the component to be manufactured. Next a planner decides how the component shall be made; what kind of machine tools shall be used for each operation of manufacture, and in what order. A ratefixer then estimates how long it should take to perform each operation. This is known as the " allowed time."

When the operative starts work on the component he will be given a card showing the allowed time for the operation which he is performing. Let us say this time is four hours. If the operative performs the operation in, say, three hours, then he has saved one hour of time, and he is paid for an hour's work at the bonus rate in addition to being paid the normal rate of so much an hour (the " time rate") for the three hours he has actually worked.

To calculate the amount owed to the operative, the allowed time and the actual time taken for the operation must therefore be recorded. As the situation varies widely from factory to factory, depending on local agreements and conditions, it is not possible to give any general rule for determining the proportions of "time pay" and " bonus pay " in an operative's weekly earnings; however, a proportion of three to one is probably not untypical.

The most obvious snag in the scheme is the difficulty of fixing the allowed time. The operative will naturally want as great a time as possible, while the ratefixer will be under constant pressure from the management to keep the time down. The ratefixer can only work from his own experience, for although tables of times for various types of operation can be compiled, their use in arriving at the time to be allowed for any actual operation tends to be suspect as the actual conditions applying in practice can seldom be adequately catered for theoretically in advance. There is thus always room for argument, and the creation of bad feeling is inevitable.

The psychological effects of a bonus system are far reaching. If a man is being " paid by results " his feeling of moral obligation to work hard may be diminished, for he may feel that he is only being paid for what he does, so that if he does nothing only he suffers, not his employer. If the bonus rate could be increased and the time rate diminished there would be a greater incentive to work; however, there might also be a greater diminution of the sense of obligation. Moreover, there is a grave moral objection to making too high a proportion of the weekly pay packet dependent upon performance and therefore uncertain in amount.

FAIR TIMES

As the time taken by an operative to perform an operation is recorded, the management can tell if one operative performs a certain operation faster than another operative, and this tends to " show up " the less skilful or agile man, which would be considered unfair by the operatives. Great care is sometimes taken to restrict output to a level which the less agile or skilful can also achieve. Moreover, the bonus scheme reduces the amount of help and useful information—know how—given by operatives to each other concerning operations of which they have had experience, because such know-how would enable one's fellow operative to perform a task more quickly than it is performed by oneself. In times of unemployment such considerations become of great importance. There is also quite a large measure of personal jealousy in many cases. It is interesting to note that at Christmas time bonus earnings invariably leap up as voluntary restrictions are temporarily suspended by mutual, if unspoken, consent.

Although most operatives will admit that such restriction does take place, they will invariably explain that the underlying cause is rate-cutting by the management; that is, that if they do the operation too fast the management will cut the allowed time, and they will have to work harder to achieve the same bonus earnings. In most factories there is an agreement between unions and management which states that a time will never be cut unless a change of method takes place, but the men will often maintain that this agreement is not kept, even though the examples they quote usually happened to someone else, and they themselves seldom have any personal experience of them. It is also alleged, possibly with some justification, that the management sometimes alters the method merely in order to cut the time. This, it is said, breaks the spirit of the agreement if not its letter.

OPERATIVE COUNTER MEASURES

Whatever the truth of this point of view, the fact remains that operatives sometimes go to inordinate lengths to ensure that their performance now is in keeping with that of the last time they or someone else performed the operation. Notebooks are kept in which details of past performances are recorded, and the calculation of how long to take this time may be very elaborate, particularly if such things as the number of components being made, the bonus rate, or the machine tool being used have altered since the last time that component was manufactured. There have been cases of men taking 20 minutes to decide to perform a certain operation in an hour.

It should be the object of ratefixing to ensure that there are no " good " jobs and no " bad " jobs; that is, to ensure that an operative can, by working at the same tempo, earn the same bonus whatever the job he is performing.

This is impossible to arrange in practice, due to the essentially unscientific nature of ratefixing. If a man is particularly skilful at one type of work and the ratefixer is rather generous in the timing of it, it may be that one man gets all the " good " jobs. It is more frequent, however, for the less good workman to be given the good jobs, and vice versa, because only in this way can the foreman prevent glaring inequalities in bonus earnings from arising; inequalities in earnings are considered by operatives to be a greater evil than inequalities in opportunities to earn. The bonus scheme is thus self-defeating.

The bonus system is seen at its worst when work is scarce. In such a situation it is inevitable that any work available should be commenced as soon as possible to avoid idleness. This may well result in work being undertaken before the system has had time to ensure that the necessary ancillaries to production (such as tools, jigs, and fixtures, special parts bought from outside suppliers, etc.) are available, with the result that the work is hampered and the allowed times, which have been arrived at on the assumption that these necessary ancillaries are available, cannot be achieved, and bonus earnings diminish through no fault of the operatives concerned.

The most serious practical, rather than psychological or social, disadvantage of the bonus scheme is its tendency to produce shoddy work. It is quite understandable that an operative is unlikely to take the same care over an operation in which speed of performance determines his earnings, as he would if his earnings were independent of output. The only way in which to be certain that the required standard is produced is completely to inspect every component. This is impossibly expensive in most jobbing factories, with the result that a large amount of rectification work has to be carried out at a later stage, usually by hand. When work of high quality is necessary the bonus scheme is replaced by a less personal incentive scheme. This is why the toolroom of a factory, in which the measuring gauges and other precision tools are produced, never works on a bonus scheme, but always on some kind of group incentive.

FORECASTING COSTS

The great advantage of the bonus system is, of course, that it provides an incentive to operatives to keep up a high rate of production without the need of close supervision to this end. In a mass production factory the " speed of the belt " acts as a supervisor, and a flat time rate is therefore acceptable. But the situation in a jobbing factory is completely different. It is not true that if bonus schemes were replaced by flat time rates the whole ratefixing apparatus could be dismantled. In modern industry it is becoming increasingly important for managements to be able to assess fairly accurately the costs of production so that realistic pricing and priority allocating is possible. A reasonably accurate forecast of the cost of making an article is essential, and this involves doing much the same sort of thing that is done in ratefixing. It is thought unlikely that the very large increase that would be required in supervisory staff could be offset to any significant degree by a reduction in ratefixing staff. It appears, therefore, that there are legitimate reasons for not replacing bonus schemes by flat time rate schemes.

There are also reasons which are not legitimate. The bonus scheme tends to place some of the responsibility which should lie with the management on the shoulders of the operatives. If the production control organisation has failed to arrange for all the necessary ancillaries to production to be available when required, the operative will usually have to spend time procuring them himself in order to minimise the time he takes to perform the operation, even though it is not his job to do so. It is the management's job to devise and efficiently to run an organisation in which operatives are enabled to be as productive as possible. If there were no bonus system management would have to take energetic steps to improve the organisation as it could no longer rely on the economic pressure of the bonus system to force operatives into doing part of the organisation's work. But the right solution is to have a good and well run production system, regardless of the method of payment.

The

'Engineering' Appointments

Section

Production Engineering Executive

A first class production engineer is required as a senior member of the Central Industrial Engineering Unit of a large light engineering Company.

This appointment will carry wide responsibility including: Investigation of new and advanced production techniques. Origination and development of special purpose machines. Automation.

Correlation of tool design.

Applicants must have had a wide experience of production engineering in a light engineering Company where advanced production techniques and methods have been successfully applied to mass produced commercial products and to batch produced specialised equipments.

Drive, initiative, and an inventive but practical mind and a true appreciation of the cost aspects of production are essential.

The commencing salary will be in the range

£1,750—£2,200

and opportunities for advancement are excellent.

Applications should be addressed to Box C 304
OFFICES OF ENGINEERING

PUBLIC APPOINTMENTS

LONDON COUNTY COUNCIL

WANDSWORTH TECHNICAL COLLEGE require in September, 1960, (1) LECTURER to teach Physics and Applied Physics to H.N.C. level; (2) ASSISTANT GRADE A to teach Maths up to O.N.C. standard.

Graduate or equivalent qualifications, industrial and teaching experience desirable. Burnham F.E. salary scales:—

Lecturer, £1370 by £35 to £1550 plus London Allowance.

Assistant Grade A, £520 by £27 10s. to £1000 plus London Allowance and additions for qualifications and training. Increments within scale for approved experience.

Application forms from SECRETARY AT COLLEGE (FE3a/En/1533/6), WANDSWORTH HIGH STREET, to be returned by 25th JUNE, 1960. C 306

GRADUATE MECHANICAL ENGINEER

GRADUATE MECHANICAL ENGINEER required by NATIONAL RESEARCH DEVELOPMENT CORPORATION, an organisation set up under the Development of Inventions Act, 1948, to develop and exploit inventions in the public interest. The work is administrative in nature and involves maintaining personal contact with research establishments; assessing inventions; arranging their development if necessary; and finally securing their commercial use, generally through licence agreements negotiated with senior management of industrial firms. Progressive salary starting within the range of £1200-£1500 according to age, qualifications and experience. Preferred age about 30. Superannuation Scheme. Send postcard for application forms, etc., quoting REFERENCE F4, to DIRECTOR OF ADMINISTRATION, N.R.D.C., 1, TILNEY STREET, LONDON, W.1. C 303

SURREY EDUCATION COMMITTEE
KINGSTON TECHNICAL COLLEGE,
FASSETT ROAD,
KINGSTON-UPON-THAMES
ENGINEERING DEPARTMENT

Lecturer or Assistant Lecturer Grade B in Mechanical Engineering according to qualifications. Salary scales in accordance with Burnham Technical Report, plus London Allowance, Lecturer: £1370 by £35 (£40) to £1550, Assistant Lecturer Grade B: £700 by £27 10s. (£15) and £37 10s. to £1150, with allowances for training, degree and approved experience.

Further particulars for each post and application form from Principal on receipt of S.A.E. C 317

LONDON COUNTY COUNCIL

CHRISTOPHER WREN SCHOOL, BLOEMFONTEIN ROAD, SHEPHERD'S BUSH, W.12. (1,500 boys, 11 to 18; G.C.E. to "O" and "A" levels; Secondary Technical approach, special courses in Building and Art.) Required, from 12th SEPTEMBER NEXT, master to teach Technical Drawing part-time up to two days a week, during school terms. Days and times by arrangement. Applications to be returned as soon as possible to the Headmaster, from whom further particulars and details of rates of pay may be obtained. Please quote reference TS2/E/1557/6. C 307

STATION ENGINEERS

AIR MINISTRY require STATION ENGINEERS (G.D.) and STATION ENGINEERS (MECH.) at R.A.F. and Ministry of Aviation Stations. The work of Station Engineers (G.D.) consists of installation, operation and maintenance of high and medium voltage electrical distribution systems, electrical power and lighting installations, control systems and generating plant: knowledge of heating and ventilating plant and diesel engines an advantage. Station Engineers (Mech.) are concerned with diesel power plant, steam and hot water heating systems, refrigeration and air conditioning and miscellaneous workshop plant, tools and equipment. Candidates must hold O.N.C. Elec. or Mech./City and Guilds Electrical Technicians Certificates/2nd class M.O.T. Certificate or equivalent and must also have had recognised apprenticeship with firm of good repute plus 3 years' employment in electrical or mechanical and engineering preferably on operation and maintenance of mine, factory or workshops plant and services. Preference to candidate with supervisory experience.

Salary ranges from £680 to £785 rising by annual increments to £850. Commencing salary dependent upon age, qualifications and experience. Opportunities for promotion up to Tech. Grade A, maximum salary £1565 (National rate). Pension prospects. 5-day week. 18 days paid leave a year initially. Internal training courses are provided and attendance at technical colleges by suitable candidates is sponsored. Overseas tours for which special allowances are payable in addition to higher salary. Applicants, who must be natural born British subjects up to age 55, should write stating age, qualifications and experience, to MANAGER (P.E.1), MINISTRY OF LABOUR, P. & E. REGISTER, ATLANTIC HOUSE, FARRINGDON STREET, E.C.4. No original testimonials should be sent. Only applicants selected for interview will be advised. G 885

NATIONAL INSTITUTE FOR RESEARCH IN NUCLEAR SCIENCE

ENGINEERS AND PHYSICISTS

Several posts with salaries between £1300 and £1800 rising to £2100 p.a. are available at the Rutherford High Energy Laboratory, Harwell, in the team which is being expanded to develop the potentialities of the 50 MeV Proton Accelerator recently commissioned there. A concentrated programme combining interesting physics/engineering research with important engineering development on a large scale is envisaged which should appeal to engineers and physicists who have the following qualifications, experience and interests.

1. A good Honours degree in Physics or Electrical Engineering or high attainments in comparable professional examinations.
2. Have experience in high or medium energy physics research and who now wish to concentrate on machine development.
3. Have experience, since graduating, in research and development in
   High power radio-frequency supplies (200 to 400 Mc/s).
   Modulator design.
   High vacuum techniques.
   Particle dynamics.
4. Have been concerned with prototype engineering in the electro-mechanical field requiring understanding of physical processes involved and a fundamental design approach.
5. Would prefer to work for a National Institute promoting fundamental research and having direct contact with universities and other research organisations in their field.

Candidates should preferably be between 27 and 35 years of age.
Salary will be progressive within the ranges quoted.
Send POSTCARD for details to—

PERSONNEL MANAGER (1720/26),
U.K.A.E.A., A.E.R.E.,
HARWELL,
DIDCOT, BERKS. C 310

TEST ENGINEERS

TEST ENGINEERS are required for work in connection with the British Nuclear Submarine Programme at Barrow-in-Furness and near Thurso, Caithness.

Applications are invited from men whose technical standard is at least H.N.C. and who should be capable of operating conventional steam machinery and analysing test results. Sea-going or power station experience would be an advantage.

Successful applicants would be required to join the Company's Contributory Superannuation Scheme when eligible. Applications which will be treated as strictly confidential should give full details of qualifications, experience and current salary, and be addressed to:

The Manager,
Marine Propulsion, Research and Development Dept.,
VICKERS-ARMSTRONGS (ENGINEERS) LTD.,
Naval Construction Works, Barrow-in-Furness. C 321

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY
GLASGOW
(IN AFFILIATION WITH THE UNIVERSITY OF GLASGOW)

DEPARTMENT OF MECHANICAL, CIVIL AND CHEMICAL ENGINEERING

Applications are invited for the following posts:—

(*a*) SENIOR LECTURER—Servomechanisms and Control Engineering.
(*b*) SENIOR LECTURER—Structural Engineering.
(*c*) SENIOR LECTURER—Engineering Drawing.
(*d*) LECTURER—Strength of Materials and Elasticity.
(*e*) LECTURER AND ASSISTANT LECTURER—Applied Mechanics.
(*f*) LECTURER—Engineering Drawing.
(*g*) LECTURER—Thermodynamics.
(*h*) LECTURER—Production Engineering.
(*i*) LECTURER—Chemical Engineering.
(*j*) LECTURER—Highway and Traffic Engineering.

In general, applicants should have an Honours Degree and professional qualifications, with teaching and/or research experience.
Excellent research facilities available.

Salary scales—Senior Lecturer, £1900 by £75 to £2275.
Lecturer, £1050 by £50 to £1400 by £75 to £1850.
Assistant Lecturer, £800 by £50 to £950.

Family Allowances and F.S.S.U.
Full details of each post and forms of application may be obtained from:

THE SECRETARY,
THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY,
GLASGOW, C.1. C 341

EDUCATION DEPARTMENT OF WESTERN AUSTRALIA
TECHNICAL EDUCATION DIVISION
PERTH TECHNICAL COLLEGE

Applications are invited for the following positions for 1961.

LECTURER/S IN STRUCTURAL/CIVIL ENGINEERING (GROUP IV)

Applicants must be fully qualified for Associate Membership of the Institution of Engineers (Australia) or equivalent Institution. They must have had experience in the Structural or Civil fields. Higher engineering qualifications and/or teaching experience will be an advantage.

Salary Range: £A1630-£A2212.

LECTURER IN STRUCTURAL ENGINEERING (GROUP III)

Applicants must be academically qualified for Associate Membership of the Institution of Engineers (Australia) or equivalent Institution. They should have had some professional experience preferably in the structural field.

Salary Range: £A1264-£A2014.

LECTURER IN MECHANICAL ENGINEERING (GROUP III)

Applicants must be academically qualified for Associate Membership of the Institution of Engineers (Australia) or equivalent Institution. They must also have had some professional experience.

Salary Range: £A1264-£A2014.

Basic wage adjustment at present £A55 is to be added to all salaries.

Appointments may be made above the minimum of the scale depending on qualifications and experience. In general increments will be of the order of £84 per annum in each of the first four years of service and £42 per annum thereafter up to the maximum.

Permission may be granted for a limited amount of consultative practice.

Applications must be made on the prescribed form T.E.1, which can be obtained from the AGENT GENERAL FOR W.A., SAVOY HOUSE, 116-118, STRAND, LONDON, W.C.1, from whom further particulars including those of travel arrangements are also available. All applications must reach the Agent General in duplicate and accompanied by a recent photograph on or before 1st JULY, 1960. C 316

CITY OF BIRMINGHAM
EDUCATION COMMITTEE
ERDINGTON TECHNICAL COLLEGE,
EDWARDS ROAD, BIRMINGHAM, 24

Principal: G. GREESLEY, D.I.C., M.I.E.E., A.M.I.Mech.E.

FULL-TIME TEACHERS required to commence duties on 1st September next, or as near as possible to that date. GRADE "A" VACANCY. Applicants should be prepared to teach Pre-Senior engineering students, including the subjects English and Social Studies. Salary: £520 by £27 10s. 0d. to £1000.

GRADE "B" VACANCY Applicants should be qualified to teach C.G.L.I. Electrical Installation Work. Salary: £700 by £27 10s. 0d. to £1150.

Increments to the above salaries may be added to the minimum for industrial experience, training and qualifications.

Forms of application and further details available from the Principal.

E. L. RUSSELL,
CHIEF EDUCATION OFFICER. C 326

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

AIR MINISTRY require ASSISTANT MECHANICAL and ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary: £805 at 25 to £1095 at 34 or over, thereafter rising to maximum of £1260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. 5-day week with 4 weeks 2 days leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience:

(i) (*a*) University degree or equivalent diploma in electrical and/or mechanical engineering with at least 2 years' apprenticeship;
or (*b*) Graduate or corporate member of I.E.E. with at least 3 years' apprenticeship;
or (*c*) Graduate or corporate member of I.Mech.E., appreciable electrical engineering experience with at least 3 years' apprenticeship;
and (ii) Have been employed for minimum of 2 years with well established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45. Forms from MINISTRY OF LABOUR, TECHNICAL AND SCIENTIFIC REGISTER (K), 26 KING STREET, LONDON, S.W.1, quoting D 158/OA. C 99

THE UNIVERSITY OF MANCHESTER

Applications are invited for up to four posts of LECTURER IN ENGINEERING (CIVIL). It is desired to make appointments from applicants particularly interested in any of the fields of Hydraulics, Soil Mechanics, Structural Concrete, Metal Structures and Surveying. The salary scale is £1050 to £1850, with initial salary according to qualifications and experience. Membership of F.S.S.U. and Children's Allowance Scheme. Applications should be sent not later than JUNE 25th, 1960, to the REGISTRAR, THE UNIVERSITY, MANCHESTER 13, from whom further particulars and forms of application may be obtained. Applications by airmail letter in the first instance will be considered from overseas candidates. C 258

LOUGHBOROUGH COLLEGE OF TECHNOLOGY
RESEARCH FELLOWSHIPS AND SCHOLARSHIPS

The Governors propose to make the following awards for the Academic Year 1960/61.

RESEARCH FELLOWSHIPS, of annual value £750, tenable for a period of up to 3 years with a possibility of further extension. Applications are invited from persons, of either sex, who hold a degree, or equivalent qualification, have obtained some industrial or research experience, and are eager to carry out research, under the general supervision of an experienced research worker, in one of the fields of engineering—applied science, human sciences and natural sciences. Fellows may be invited to undertake a limited amount of occasional tutorial work or laboratory supervision for which they receive additional payment.

RESEARCH SCHOLARSHIPS, of annual value £350 to £500, according to age and circumstances, for a period of 3 years. Applications are invited from holders (of either sex) of a degree, or equivalent qualification, who wish to obtain research training whilst carrying out research work, in one of the above mentioned fields, in association with an experienced research worker, that may lead to a higher academic award. Scholars may be invited to undertake a limited amount of tutorial work and laboratory supervision.

Fellows and Scholars may reside in a Hall of Residence.

Applications should be made to the ACADEMIC REGISTRAR, quoting reference 9/D. C 343

NORTHAMPTON COLLEGE
OF ADVANCED TECHNOLOGY
St. John St., London, E.3.1

requires

(1) LECTURERS and SENIOR LECTURERS with honours degrees and industrial or research experience for the following subjects:
MECHANICS OF FLUIDS
MECHANICS OF MACHINES
APPLIED THERMODYNAMICS
STRENGTH OF MATERIALS

(2) ASSISTANT LECTURER in ENGINEERING DRAWING, preferably with degree or equivalent, and industrial experience.

These vacancies arise from the continued expansion of the College in Degree, Diploma in Technology, and post-graduate studies.

Salary scales:
Senior Lecturer, £1588 rising to £1801,
Lecturer, £1408 rising to £1601,
Assistant Lecturer, initially in range £828 to £1263, rising to £1291 to £1396.

Particulars and forms of application are obtainable from the SECRETARY. C 342

CITY AND COUNTY OF BRISTOL
EDUCATION COMMITTEE
BRISTOL TECHNICAL COLLEGE

The Governors invite applications from suitably qualified and experienced persons for the following posts in the Engineering Department, with effect from 1st SEPTEMBER, 1960, or as soon as possible thereafter.

1. LECTURER for National Certificate courses with experience at least to Ordinary National Certificate level in the teaching of Applied Mechanics, Mathematics, Heat Engines and/or Fluid Mechanics.
2. ASSISTANT GRADE B to teach, mainly to City and Guilds courses, a selection from the following subjects:
   Engineering Science, Workshop Technology, Workshop Practice, Engineering Drawing and Workshop Calculations.
3. ASSISTANTS GRADE A (TWO) to teach Workshop Practice to standard of Intermediate Certificate of City and Guilds course in Machine Shop Engineering. Ability to assist with early stages of other engineering craft courses an asset.

Burnham Technical Scale Salaries.
Lecturers (Men) £1370 to £1550 per annum.
Assistants, Grade B (Men) £700 to £1150 per annum.
Assistants Grade A (Men) £520 to £1000 per annum.
Additions to scales A and B for graduation and training.

In case of assistants A and B, point of entry on scale will allow for previous approved experience.

Application forms—returnable within two weeks from appearance of this advertisement—and details from REGISTRAR, BRISTOL TECHNICAL COLLEGE, ASHLEY DOWN, BRISTOL, 7.

Candidates who submitted forms in response to an earlier advertisement for post No. 1 should indicate by letter if they wish their applications to be reconsidered. C 338

BRITISH COUNCIL
SCIENCE OFFICER (ENGINEER)

Vacancy in GRADE SENIOR SCIENTIFIC OFFICER. Appointment is normally on probation for permanent, world-wide service, with the prospect of promotion to senior posts. The officer serves initially in the Science Department in London, later in a science post overseas, eventually in general duties overseas or at home. (Alternatively appointment to London post only will be considered).

The Council's work in Science (pure and applied) is, broadly, to make known overseas current scientific developments in the United Kingdom. In London the Science Officer will normally advise on his branch of the sciences; when overseas on all scientific subjects (including medicine).

Candidates, preferably between 24 and 36, must be British-born British subjects, graduates with honours in Engineering, with corporate membership of I.C.E., I.Mech.E., or I.E.E. At least two years' post-graduate experience and broad scientific interests are necessary.

Present London salary scales (men): Senior Scientific Officer £1233 to £1460; Scientific Officer (entry under age 26), £655 to £1150. Superannuation Scheme, with transfer arrangements. When overseas, also: Oversea allowance (married £700 to £1500; single £300 to £1000, according to country), children's allowances, free accommodation, etc.

Write, quoting C.3.E6(60) and enclosing a stamped addressed foolscap envelope, to DIRECTOR, RECRUITMENT DEPARTMENT, BRITISH COUNCIL, 65, DAVIES STREET, LONDON, W.1, for further particulars and application form, to be returned completed by 5th JULY, 1960. C 337

UNIVERSITY OF SYDNEY

LECTURESHIP IN CIVIL ENGINEERING

Applications are invited for the above-mentioned position. Candidates should have a higher degree and have had some teaching experience in the subject Surveying.

The salary for a Lecturer is within the range £A1730 by £105 to £2435 per annum, plus cost of living adjustments (at present £A5 per annum) and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant.

Under the Staff Members' Housing Scheme, in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the SECRETARY, ASSOCIATION OF UNIVERSITIES OF THE BRITISH COMMONWEALTH, 36, GORDON SQUARE, LONDON, W.C.1.

Applications close, in Australia and London, on 29th JULY, 1960. C 336

COUNTY BOROUGH OF BURTON UPON TRENT EDUCATION COMMITTEE TECHNICAL COLLEGE

Principal: E. WHITE, M.Sc.(Econ.)

Required in September, 1960, or as soon as possible after that date, LECTURER IN PRODUCTION ENGINEERING to take Workshop Technology and associated subjects including Workshop Practice to H.N.C. and Final City and Guilds of London Institute level. Candidates should have post H.N.C. qualifications and good industrial experience. A sound knowledge of machine tools and the ability to take high level practical work is required.

Salary will be in accordance with the Burnham Technical Scale.

Forms of Application, which may be obtained from the undersigned upon receipt of a stamped, addressed foolscap envelope, should be sent as soon as possible to the PRINCIPAL, THE TECHNICAL COLLEGE, BURTON UPON TRENT.

A. H. BLAKE,
Director of Education.

EDUCATION OFFICE,
GUILD STREET,
BURTON UPON TRENT C 333

ELECTRICITY SUPPLY BOARD (DUBLIN) VACANCIES FOR STRUCTURAL DESIGN ENGINEERS (TEMPORARY)

THE ELECTRICITY SUPPLY BOARD has vacancies on its CIVIL ENGINEERING DESIGN STAFF at its Head Office in Dublin for:—

(*a*) ENGINEERS not over 35 years of age with at least eight years' experience on the design and construction of civil engineering work, the major portion of which should be on heavy reinforced concrete and/or structural steel work; salary will be not less than £1009 per annum in a Scale rising by annual increments to a maximum of £1275 per annum.

(*b*) ENGINEERS not over 30 years of age with at least four years' experience as set out above for (*a*); salary will be not less than £81 7per annum in a Scale rising by annual increments to £1162 per annum.

Candidates must possess a University degree in Civil Engineering or an equivalent qualification. Design experience on steam generating stations would be an advantage.

The commencing salaries within the above scales will depend on qualifications and the nature and extent of experience, but will be not less than the figures mentioned above.

The appointments will be on a temporary basis and are expected to continue for at least three years.

Applicants should clearly indicate the particular position(s) in which they are interested; applications should set out the candidates' age and full details of their qualifications and experience (with dates) and should reach the Personnel Officer, 27 Lower Fitzwilliam Street, Dublin, not later than fourteen days from the date of this publication.

J. G. GARGAN,
Secretary. C 334

GRADUATE RESEARCH ASSISTANTS

are required by

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

St. John St., London, E.C.1

or projects in Applied Photoelasticity, Fatigue of Metals and Impact Testing. Those appointed will be expected to work for a Higher Degree of London University. Salary about £500 per annum including payment for some assistance in laboratory and tutorial classes. Candidates graduating this year will be considered.

Further particulars and application forms are obtainable from the Secretary. C 345

APPOINTMENTS OPEN

ENGINEER

ENGINEER for Inspection of Cranes and Lifting Plant required by leading Insurance Company. Must have drawing office experience of design of Cranes also National Certificate in Mechanical Engineering. Areas South Essex and Liverpool. Starting salary £800—other benefits—not over 38 years—permanent.—Write BOX EG 540, L.P.E., ROMANO HOUSE, 399/401, STRAND, LONDON, W.C.2. C 322

DETAIL AND SCHEME DRAUGHTSMEN

Detail and Scheme Draughtsmen required. Experienced Sheet Metal Work for Ventilating and Dust Recovery Plants, etc.—'PHONE: VISCO CRO. 4181. C 245

RESIDENT ENGINEER

RESIDENT ENGINEER for reconstruction of the Swing Bridge at Caernarvon. Approximately 9/12 months appointment commencing July/August, 1960. Experience of welding essential. Salary £1000 per annum plus expenses allowance.—Applications giving full details of experience should be forwarded to the CONSULTING ENGINEERS, F. R. BULLEN & PARTNERS, DACRE HOUSE, DEAN FARRAR STREET, LONDON, S.W.1. C 244

GEAR DESIGN ENGINEER

Gear design engineer required with experience marine gearboxes or V.P. propellers. Vacancy is in busy and expanding Technical Department, where good salary will be paid for the right man, having H.N.C. or equivalent. Existing holiday arrangements respected. Superannuation scheme. Free life insurance.—Apply: TECHNICAL MANAGER, MODERN WHEEL DRIVE, LTD., LINDO LODGE, STANLEY AVENUE, CHESHAM, BUCKS. C 232

AN ENGINEERING COMPANY

serving the Gas, Petroleum, Chemica and Steelmaking industries requires a

CHARTERED CIVIL ENGINEER

Candidates should be preferably 30/35 years of age with contracting and design office experience. Employment at first will be in the company's drawing office with opportunities later to take charge of projects operated from Head Office or from field project offices at home and overseas. Pension scheme. Assistance with housing.

Details of training, experience and salary required to BOX C 198, Offices of ENGINEERING.

ASSISTANT ENGINEER

THE BOWATER PAPER CORPORATION LIMITED invites applications for the post of ASSISTANT ENGINEER (HEATING AND VENTILATING). The duties will include the design and selection of equipment associated with Factory and Office Block heating and air conditioning and the design of special purpose ventilation plant connected with paper machinery. The applicant must have received a thorough training in heating and ventilating practice and held a responsible position for at least two years. The qualifications required are H.N.C. or A.M.I.H.V.E. Applications in writing stating salary required should be addressed to THE CHIEF ENGINEER, THE BOWATER PAPER CORPORATION LIMITED, ENGINEERING DIVISION, NORTHFLEET, KENT. C 328

APC RESEARCH & DEVELOPMENT

Due to the considerable expansion in the scope of the work undertaken at the Company's Research and Development Laboratories, Heston, Middlesex, the following interesting and responsible positions now exist.

1. DEPUTY HEAD OF ENGINEERING DIVISION

The Division deals with development problems in nuclear engineering involving structural analysis, fluid mechanics and heat transfer.

2. GROUP LEADER—STRUCTURES

The Group is engaged in experimental stress analysis of reactor structures and vessels and in developing reactor components.

3. GROUP LEADER—MATHEMATICAL SERVICES

The Group's main functions are to analyse the results of experiments including metallurgy, heat transfer, stress analysis and carry out theoretical studies concerned with design of experiments.

4. SENIOR TEST ENGINEER

To supervise the mounting and running of experiments on several new test rigs.

5. SUPPLY ENGINEER

To be responsible for the issuing of enquiries, progressing of orders and works inspection of test rigs and associated equipment.

Applications are invited from suitably qualified and experienced persons and full details should be sent to:—

The Personnel Manager (Ref. E/118), ATOMIC POWER CONSTRUCTIONS LIMITED, P.O. BOX 99, 28 Theobalds Road, London, W.C.1 C 309

MANAGEMENT CONSULTANTS

QUALIFIED ENGINEERS

QUALIFIED ENGINEERS with personality and drive are invited to apply for appointments available in the autumn. The work is extremely interesting and covers a wide range of industrial problems. It offers experience, remuneration and status equal to senior executive positions in industry and there is ample scope for advancement and opportunities for service abroad if desired. The work includes the development and introduction of:—

Factory layout, mechanical handling and automation.

General organisation and production control.

Purchasing, stock control and stores organisation.

Planning engineering, methods and work study.

Incentives, training and personnel administration.

General business and project surveys in a wide range of industries and often in conjunction with marketing, technical or financial consultants.

Applicants should be aged 26-35 with a good general education and should possess a university degree or equivalent qualifications. Remuneration includes cash profit sharing and generous non-contributory pension scheme with life cover. Replies, which will be treated in confidence, should include brief personal details and should be addressed to:—

PRODUCTION ENGINEERING LTD
12 Grosvenor Place
London, S.W.1
quoting reference QJ

C 332

TEXACO TRINIDAD, INC.

requires a

PIPING AND PROCESS EQUIPMENT DRAUGHTSMAN

for service in TRINIDAD

Applicants must hold a Higher National Certificate in Mechanical Engineering or an equivalent qualification, and Graduate or Associate Membership of the Institution of Mechanical Engineers is desirable. They should have served a mechanical engineering apprenticeship with manufacturers of high pressure boilers or of pressure vessels and allied equipment for the petroleum refinery or chemical industries, with emphasis on fabrication and drawing office work. Subsequent experience should consist of seven or more years in the design and detailing of pressure vessels and piping to Code requirements, and of non-pressure vessels and tanks including pipe stressing. They should be able to apply API-ASME Codes and to lay out process plant equipment and piping. Some experience as a section-leader with responsibility for organising and progressing work is essential.

Applicants should hold a current driving licence and be between the ages of 27 and 35. The starting salary for this appointment will be up to £1600 p.a. according to qualifications and experience, and subsidised accommodation, schooling for children and long leave in this country at the end of each three year tour are provided.

Please write with brief particulars in the first instance to:—

The Personnel Officer, Trinoil (U.K.) Limited

29/30 Old Burlington Street, London, W.1

(Please quote J.43) C 319

EXCEPTIONAL OPPORTUNITY

for

YOUNG DESIGN ENGINEER (Aged 25-30)

with H.N.C. and some years' experience, to develop his potentialities with a virile and expanding organisation. Knowledge of steel structures and electrical control systems desirable.

● GENEROUS SALARY RANGE ● PENSION SCHEME
● INTERESTING & VARIED WORK ● TRAVEL OPPORTUNITIES
● CONGENIAL ATMOSPHERE

Write or telephone for interview to:

THE TITAN LIFT CO. LTD., PANCRAS RD., LONDON, N.W.1
TERminus 5138. C 315

BRITISH OXYGEN GASES LIMITED

Development Group, Harlow

British Oxygen Gases Limited have the following vacancies in their Development Group. The work is in connection with the development of equipment of a specialised nature in the compressed gases field.

DEVELOPMENT ENGINEER

Applicants should have a recognised technical qualification, preferably of pass degree or equivalent standard, as well as sound previous experience of design and development or experimental work in an appropriate direction. Familiarity with mechanical devices, scientific apparatus (not exclusively optical), instrumentation techniques, or systems involving the transfer of fluids would be an advantage.

TECHNICAL ASSISTANTS

Applicants should possess an O.N.C. or equivalent and have had some experience of test and experimental work of a nature parallel to that indicated above for the Development engineer post.

MECHANICAL DRAUGHTSMEN

Applicants must have a number of years' experience in the light engineering field, preferably with particular experience in a Development Drawing Office.

Housing assistance is available at Harlow

There are good prospects as the activities of this section are expanding.

Write stating brief details to the

Chief Development Engineer,
British Oxygen Gases,
Pinnacles Works, Harlow.

C 327

FOREMAN

GLAXO LABORATORIES LTD. require a FOREMAN to take charge of Boiler and Power Houses and ancillary services equipment. Experience of operating and maintaining steam boilers and associated equipment including turbo-alternators is essential, whilst experience of water-tube boilers in particular and ammonia refrigeration plant, would be an advantage. A commencing salary of £760 per annum is envisaged. Excellent conditions of service including Pension Scheme and participation in the Company's profitability.—Apply PERSONNEL OFFICER, GLAXO LABORATORIES, LTD., GREENFORD, MIDDLESEX. C 331

DEPUTY CHIEF OF PLANT

SÃO PAULO LIGHT S.A.—SERVIÇOS DE ELETRICIDADE, a Company in Brazil and a subsidiary of the Canadian corporation Brazilian Traction, Light and Power Company Limited, invite applications from suitably qualified men for the position of DEPUTY CHIEF of its PIRATININGA POWER STATION. The power station was completed about five years ago and is situated near São Paulo (population over 3 millions; temperate climate, 2,200 ft. above sea level). The plant comprised initially 2 × 100 MW., 1,800 r.p.m. steam turbo-generator units each supplied at 850 p.s.i., 900 deg. C. by one 850,000 lb./hr. oil fired boiler and has been recently expanded by the addition of two 125 MW. reheat units, 1,800 p.s.i., 1,000 deg. F. Applicants should have sound technical knowledge and good practical experience in the administration, operation and maintenance of steam-electric power stations; should also be of strong character with an aptitude for supervision and the maintenance of harmonious labour relations. Good salary, three years' agreement with first class passage both ways; four months paid leave after three years service.—Written application in the first instance should be made to MR. OSBORNE MITCHELL, GENERAL MANAGER, CANADIAN-BRAZILIAN SERVICES LIMITED, 9/12, CHEAPSIDE, LONDON, E.C.2. C 329

MECHANICAL ENGINEER

If you have a good honours degree in Mechanical Engineering plus Graduate or Associate Membership of the Institution of Mechanical Engineers and would like to join the Commonwealth's largest glass manufacturing organisation, you are invited to write about yourself to the PERSONNEL OFFICER (GRADUATE RECRUITMENT), PILKINGTON BROTHERS LIMITED, ST. HELENS, LANCASHIRE.

You would be responsible direct to the Works Mechanical Engineer for the installation of new plant and improvement and maintenance of existing plant, including the Pilkington invented "Twin Grinder" licensed to flat glass manufacturers throughout the world. You would find ample scope for initiative and responsibility and there would be opportunity for early promotion within the Group. C 308

DESIGN ASSISTANT

DESIGN ASSISTANT required by Marine Engineering Company, in Clyde area for work on Turbine and Oil Engine Machinery. Knowledge of Torsional Vibration problems, estimation of power requirements for ships, Propeller design and preparation of Heat Flow Charts, etc., desirable.

Applicants should be capable of working on own initiative with minimum supervision and preferably hold an Engineering degree or equivalent.

Superannuation Scheme available after qualifying period of satisfactory service. Please state fully experience, age and qualifications.—Write 2755, WM. PORTEUS & CO., GLASGOW. C 252

CHIEF INSPECTOR

required for

LARGE COMMERCIAL VEHICLE FACTORY NEAR LONDON

Applicants must have experience in Modern Production Methods, including Heat Treatment, Sheet Metal Body Welding and Assembly Operations and Finish Painting.

Applicants should be good disciplinarians and not over 45 years of age.

Staff Pension Scheme and Social and Recreation facilities available.

Box No. CR 3475, A.K. ADVG.,
212a, Shaftesbury Avenue, London, W.C.2.

C 293

DRAUGHTSMAN

REQUIRED BY

NORTH THAMES GAS BOARD at WESTMINSTER, S.W.1

for the design and detailing of reinforced concrete structures and foundations associated with gas works.

Higher National Certificate is a minimum qualification.

Starting salary according to qualifications and experience.

The appointment will be of a permanent nature and the successful candidate will be required to join the Board's contributory pension scheme.

Applications, stating age, qualifications and experience, should be sent to the STAFF CONTROLLER, NORTH THAMES GAS BOARD, 30, KENSINGTON CHURCH STREET, W.8 quoting reference EG/767. C 330

ELECTRICAL ENGINEER

ELECTRICAL ENGINEER required by large textile group in Dundee and district. This appointment is at Managerial level, and the man selected will be directly responsible to the Chief Engineer for the planning, installation and maintenance of all electrical plant and equipment in the group. The post is salaried and superannuated. Applicants should be Corporate Members of the Institution of Electrical Engineers.—Apply, giving full particulars of age, experience and qualifications, to the STAFF MANAGER, JUTE INDUSTRIES LTD., MEADOW PLACE BUILDINGS, DUNDEE. The closing date for applications will be 22nd JUNE, 1960. C 281

ASSISTANT WORKS ENGINEER

ASSISTANT WORKS ENGINEER (MECHANICAL) required by old-established manufacturing company in the Midlands (non-engineering product), with experience in the design, layout and installation of process equipment and factory services. Applicants will be responsible for the co-ordination of the department engineering sections and the preparation of estimates, and must be Corporate Member of the Institute of Mechanical Engineers. Age range 30-40. —Write giving details of experience and salary to BOX C 323, Offices of ENGINEERING.

CHEMIST OR CHEMICAL ENGINEER

O. W. ROSKILL, INDUSTRIAL CONSULTANTS, 14, COLLEGE STREET, S.W.1, have an opening for a YOUNG CHEMIST or CHEMICAL ENGINEER with a university education for technical market research and other consulting work. An unusual combination of scientific outlook and ability to draft well is required, together with wide rather than highly specialised interest in technological matters. C 320

GKN

The Guest Keen and Nettlefolds Group of Companies
wish to make the following appointment in one of their constituent companies.

INDUSTRIAL ENGINEER

The Production Manager of a Group Company which manufactures steel reinforcement and similar products, requires an Assistant to take part in the development of Work Study and systems of Production Control in the four works of the Company.

Applicants who should be aged about 30 must be qualified engineers, preferably with a degree, and should have had training and experience in Work Study methods. Experience of Production Control methods and plant layout would be an advantage.

Applicants should write, giving details of age, qualifications, career to date, etc., to the

Group Personnel Officer,
Guest, Keen and Nettlefolds Ltd.,
66, Cannon Street, London, E.C.4.

All applications will be regarded as strictly confidential. C 305

QUALIFIED ENGINEERS

Consultants require QUALIFIED ENGINEERS aged 25-40 with experience of planning, production control, estimating and rate fixing.—BOX C 344, Offices of ENGINEERING.

THE HARLAND ENGINEERING COMPANY LIMITED · ALLOA

require several

SENIOR DRAUGHTSMEN

in connection with an expanding development programme in the field of centrifugal pumps, hydraulic turbines and medium/large electrical rotating machinery.

Experience in these products whilst advantageous is less important than thorough knowledge of modern mechanical engineering, stress analysis, materials selection and application, and up to date draughting methods.

The Company offers good salaries and working conditions with contributory pension scheme, extended holidays after twelve months. A company house is available or assistance with house acquisition or purchase can be provided.

Replies, giving full particulars of age, qualifications and experience, will be treated in strict confidence and should be sent marked "PERSONAL" to—

CHIEF DRAUGHTSMAN,
B.E.P. WORKS,
ALLOA, SCOTLAND. G 882

ADVERTISEMENT RATES

'Engineering' Appointments Section

CLASSIFICATIONS: Public Appointments, Appointments Open, Appointments Wanted.

TYPES OF ADVERTISEMENTS:

(a) "Appointments Illustrated" and illustrated careers advertisements: photographs or drawings may be used in conjunction with type matter.

Rates:	per page (12 in. by 9 in.)	£100
	half page	£54
	quarter page	£29

(b) Semi-display: type matter, with or without surrounding rule, name block or symbol.

Rates:	per page (12 in. by 9 in.)	£100
	per half page	£54
	quarter page	£29
	per single column inch	£2 14s.

(c) Single column "run-on" advertisements: approximately 6 words to the line, 12 lines to the inch.

Rate per line .. .. 4s. 6d.
(Minimum charge 18s.)

SERIES DISCOUNTS: 5 per cent. on 6 insertions; 10 per cent. on 13; 15 per cent. on 26; 20 per cent. on 52.

BOX NUMBER: 2s.

Companies

Jaguar Move Means More than Expansion

THE JAGUAR CAR Company was formed as a private company in 1933 to buy the SWALLOW COACHBUILDING Company. Well before the outbreak of the Second World War its SS Jaguar cars were internationally known as fast sports cars and high performance saloons.

The post-war years have been a long succession of triumphs under the leadership of Sir William Lyons. The company is now producing 450 cars a week and is "urgently" in need of room to expand. Greater output was needed to meet an estimated increase of 25 per cent in the valuable exports to the United States alone. These are running at between $40 million and $44 million a year.

Now the extra facilities are obtained at one blow by the purchase at an undisclosed figure of the 56 acre Coventry factory of the DAIMLER Company, the oldest company in the British car industry. Daimler fortunes have been beset by rumour for years past and its enormous factory has capacity which has not been fully employed.

For this reason the Jaguar Company has been able to state that, while obtaining the scope for its own expansion the production of Daimler cars, buses and armoured vehicles will continue, as will the service and spares division.

The introduction of the special motor road to Britain, and its many times faster adoption overseas, coupled with the growth in all the continents of demand for commercial and passenger road transport means that the bus side of the Daimler company, under Sir William Lyons' command, could become very much more significant. There may be little enough signs for the Jaguar chiefs to see an attractive long term future in armoured fighting vehicles. The dependence on defence ministries, in their monopoly positions, turns the thing into a gamble.

The extra million square feet of factory space revolutionises the possibilities of bringing out one or more new models, either under the Jaguar or Daimler flags.

For the Birmingham Small Arms Company there is the question of what to do with all the money. The board has said that its immediate intention is to use these funds for the expansion of current activity and, when appropriate, to acquire further interests in the engineering industries.

Ford Takes Truck Production to Slough

The removal of the car companies' commercial vehicle and tractor production to the more distant parts of their empires continues. While BMC gets the benefit of concentrated car manufacture at Longbridge, and JAGUAR expands into its newly acquired million-plus square feet, the FORD MOTOR Company frees itself for greater singleness of purpose at Thames-side Dagenham.

Two months ago it was the movement of the tractor capacity to the new town of Basildon. Now the company announces that in future most of its trucks will be made at Langley, Slough, in Buckinghamshire. The assembly of 5 cwt and 7 cwt vans will continue at Doncaster.

Engines, gearboxes and axles for the Langley vans and trucks will still be made at Dagenham. With the great London road chaos between Dagenham and Langley an economist might point to the cost in time and detours. Presumably the more than £3 million development at Langley, where Ford's have had an engine conditioning plant for 12 years, was the best of the possible alternatives.

Van production is due to start up in August and truck output in October. There is no plan immediately to increase commercial vehicle output.

Another motor industry move, the OWEN ORGANISATION has bought CHARLES CLARK & SON (COMMERCIAL VEHICLES).

TUC Wants Companies Kept Out of Politics

Is the Trades Union Congress about to urge its affiliated unions to give up their well known interest in politics?

The question is brought about by the TUC's evidence to Lord Jenkin's committee on Company Law. The trade union chiefs from their Bloomsbury headquarters have told the committee that companies should be prohibited from making donations to the funds of a political organisation or from spending money on activities "the prime purpose of which is to further political objectives." The excuse given for advancing this proposition is that the TUC claims "concentrations of wealth" at the control of companies may be used to distort the democratic process.

No Clear Idea

There is a slightly unreal air about all this. The TUC, or any union or the Labour Party, feels itself free to threaten any industry they like with being handed over to the civil servants. From within the Labour Party believable voices have observed that before 1945 nobody had thought out how to apply nationalisation once the power to bring it about had been conferred by the voters.

There is nothing to suggest that any very clear ideas of how companies, that a Labour administration in its own phrase judged to be "failing the nation", could be better run. What the Jenkins committee have to say on whether or not an industry defending itself in public is "distorting the democratic process" remains to be seen.

What is inescapable is that a Labour politician, putting up any kind of competent performance at all, has the incalculable advantage that the shadow of private interests which a company cannot begin to escape, can in no way fall across his message to the electors. Perhaps if their political wing had enjoyed success the TUC leaders would have felt less keenly the arguments of industry.

Magnanimously enough they go on to say that there can be no objection to companies making payments for genuinely charitable purposes. Companies do not need the permission of the TUC for this side of their activities. Perhaps the TUC was thinking of its relations with the Labour Party.

When the TUC says that collective bargaining cannot work unless employers give adequate information on the business they are asking that the practice of the best companies in this respect should become general. This is worthy of support.

Annual Accounts

It is the same suggestion, the rest catching up with the leaders, when the unions urge that all companies be required to file financial accounts yearly—more than three-quarters of all companies are at present exempt private companies, under no such salutory obligation.

The TUC, advocating that assets should be shown in the balance sheet at a recent valuation and not at first cost less depreciation, is again following the practice of some of the leaders. Group accounts which say nothing of the performance of individual companies are not much more than a pleasant exercise for the layout man and the artists paid a fee for drawing the works.

On take-over bids the TUC wants all circulars to be filed with the Company Registrar and copies sent not only to the shareholders but to the workers representatives. The shareholders too may perhaps support the TUC's suggestion that any bidder be required to publish his identity and intentions towards the company's future and its personnel.

Fireproof Phoenix from Wolverhampton

The COSELEY BUILDINGS Company, of Wolverhampton, have received an order for buildings from Canada in a way

that can accurately be called dramatic.

The story began with a building supplied to SUPERIOR PROPANE Limited, of Lachine, Quebec, by Coseley in 1954. Five years later, in the winter now past, the plant of Superior Propane was severely damaged by fire and blast. Fire at the plant was accompanied by the explosion of gas (see picture) and by some loss of lives.

At the end of it all the Coseley building, a steel frame clad in corrugated asbestos cement sheets, was standing alone, and relatively undamaged. Mr. P. H. Longley, Canadian associate of the company, said: At times during the fire the building was completely enveloped in flames from exploding gas tanks. Even so it came through the explosion and prolonged terrific heat practically unscathed, its contents undamaged. . . ."

The order placed with Coseley to replaced buildings destroyed by the flames is being treated as an emergency production job. Shipment of the units is expected to be made a week from now.

Pipped by Permindex

Europe's first permanent fair has just come into being. Chicago already has the Merchandise Mart and New Orleans its International House but Permindex, opened in Rome last month, is the first venture of this kind on this side of the Atlantic. The idea for Permindex is relatively new, but the setting is the pre-war EUR, the exhibition centre built by Mussolini on the way out of the city towards Ostia. EUR was intended by Mussolini as the site for the Universal Exhibition of 1942.

Various international exhibitions have been held there since the war, but it is only in the past year that the centre has really been in full working order. The money for Permindex has come from various sources. Crédit Suisse has put up 30 per cent and American banks and financiers 25 per cent, apart from what the Italians themselves have found.

What does Permindex have to offer? Its big attraction to the foreign manufacturer is that it gives him an address with banking facilities, interpreters, travel agents and so on, all laid on. But this is not the Brussels Fair over again.

A limited range of goods is displayed by categories, not nationalities. But there is a very full library of catalogues and documentation films, records, tapes and other media for describing the products available. Space at Permindex has been rationed out between the various industrial countries. Britain has an area amounting to some 6 per cent of the total exhibition area available.

At first there was considerable opposition to the idea of participating in Permindex on the part of the French. There were complaints about the cost of stands and a general niggardliness until it was realised that American and Swiss capital were principally involved. Once it was clear that this was not the Italians stealing a march on them, the French stopped grumbling and rushed to take space, especially in the furniture section.

Regret in Paris

Some trade associations have mounted exhibits, but many French firms have put their goods on show themselves. There is still general regret that no one thought of putting on an exhibition of this kind in Paris.

Another cause of grumbling, and this time not confined to the French, is that space has been let to the Japanese. To the free-trader all competition is good but even the Common Market countries are worried at the prices of some of the goods displayed. Not altogether surprisingly the loudest complaints about Permindex have come from within Italy itself. The merchants of Milan, long the acknowledged leaders of Italian trade and industry, are full of chagrin at being pipped at the post by Permindex.

In Milan the benefits of a permanent international exhibition is not a popular subject just now.

The existence of Permindex and the great public interest in the British Trade Fair in New York are reminders, too, of the sad absence of such a permanent industrial show in the United Kingdom.

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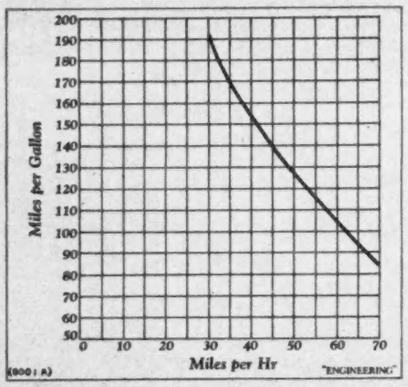

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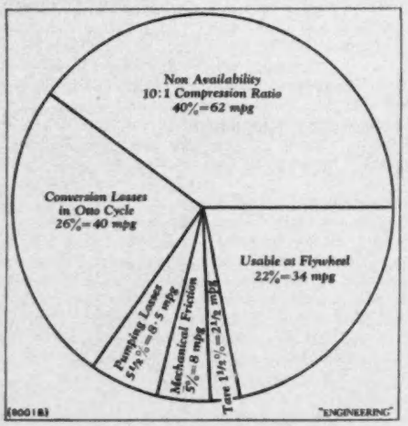

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Improvements in engine structures have greatly increased the usable rate of pressure rise in the cylinder and further developments may lead to recovery of some of the losses due to delayed burning and heat loss to the coolant. Up to 5 per cent might be recovered.

Pumping losses could be reduced by use of an unthrottled air charge, the improvement varying with engine speed. At about 40 m.p.h., some 80 per cent of the total pumping loss might be recovered, and a gain in thermal efficiency of about 4 per cent seems possible. Improvements in lubrication, bore-stroke ratio, piston ring design, piston shape, may eventually give a 2 per cent better total thermal efficiency.

Finally, tare losses may be decreased by a more economical mechanism than the accelerator pump and by some method of optimum setting of the spark. About a 1 per cent gain in thermal efficiency might be expected.

Therefore in the future a saving of about 20 per cent in thermal efficiency might be achieved; this would then rise to 42 per cent, giving 65 m.p.g. in the absence of drive train losses and provided too many engine-driven gadgets are not added. Clearly, no single new invention or development is going to produce this figure. It will be the result of painstaking and gradual improvement in overall engine design.

Manufacturing Techniques of the Future

A considerable effort is needed to make the forging and casting processes more efficient in order that machining of components can be cut to a minimum.

By F. Griffiths

Chief Production Development Engineer, British Motor Corporation

It is proposed in dealing with the future trends in manufacturing techniques, to discuss those which will directly affect the very vast and growing consumer industries, and the effects that these new techniques will have upon the capital equipment industries which supply the means of production for the consumer industries.

The more remote techniques which are developing around such industries as those concerned with the manufacture of aeroplanes, missiles, and other things of a like type are, as yet, a long way from possible usage in the mass production industries.

When we look at the materials in common usage at the present time, other than plastics, and the production techniques which are used to fabricate these materials, we very soon realise that there has been no or very little fundamental change since the industrial era opened. For instance, the foundry, except when it is concerned with the smaller aluminium parts and a certain amount of iron which are produced from metal dies, has changed its fundamental techniques very little since it first became a unit of production. Certainly a small measure of mechanisation has taken place, but the casting normally produced has not improved in accuracy. The forge, although we have moved away from the anvil and sledge-hammer by using dies and mechanical hammers, is still an extremely crude process. The fundamental process employed in producing steel bar, is still thoroughly unorganised, with an end product of very crude dimensional accuracies, and with even cruder standards of finish. The use of metal in sheet form has produced a much higher standard of raw material, but still with the same appalling wastage that occurs in the other processes.

The sum total of these has been that a new highly expert industry has come into being centred around what is now called the machine shop. The capital equipment which is produced in the machine shop, solely for the purpose of sizing and finishing the products of the foundry the forge and the bar steel mill, is today of an extremely accurate and complicated nature, there having been an enormous degree of development and expertmanship engineered to produce the work that is required out of the machine shop. In fact, today, engineers are designing component parts, not around what is actually required of the component part, but around how it could be manufactured employing all this very expensive capital equipment that has arisen because of the crude basic components that are fed into it. It is obvious that the basic processes have been starved of the expert engineering which has gone into the machine shop. Not only are these processes in themselves crude, but the standard of the manufacture and maintenance of the tools and the plants are also of a very unsatisfactory nature. It is also obvious that it is extremely foolish to produce the great quantity of components that are required by the consumer industries, today and in the future, with these undeveloped basic processes. It is necessary for a very large effort by production engineers to move the concentration of engineering and capital from the machine shop into the basic processes, and the results of such action will be very important.

An improvement in the basic industries today could quite easily save far more money in the cost of the component parts than any action could possibly produce in the machine shop. Our processes and our thinking have been generated around a labour unit of cost, with capital and material cost being very much a second and third consideration. In the machine shop, mechanisation and automation have now reduced the labour unit of cost to such small proportions, that even quite a small saving in material or capital amortization could be of infinitely more value, and can be much more easily obtained, if we direct the emphasis of engineering skill along the right path.

The effect on the machine shop of any such action as an improvement in the basic processes could be very considerable. There is no doubt that one of the great problems in machine shop production for the consumer industry is the inconsistency of size and machineability of the component parts, as produced by the present methods in the basic processes. An improvement of this would facilitate production in the machine shop to an extent out of all proportion to the effort involved. Tool life could be immensely improved, far more than by improvement in the actual cutting materials that we use. The amount of capital involved in removing material would also be greatly reduced. In fact, the machine shop could be quite a small unit comprising mainly of sizing and finishing machinery. The cost of capital equipment for a given component would also be of very different proportions to what they are today, because much less would be required.

We will now consider, in relation to metals, what has to be altered in existing manufacturing techniques to obtain this, and what new techniques are likely to evolve in the near future.

In the cast iron foundry, at the present moment the techniques that are being used still depend to a very large extent on the operator's acquired skill. For instance, core making, no matter how mechanisation has been put around it, still involves the use of a human aptitude. The removal from the core box of moist sand with all the sagging possibilities before baking takes place is obviously capable of producing very great inaccuracies, and the use of green sand mouldings with all the rapping that occurs to get the pattern out of the mould also produces inaccuracies. The impossibility of accurate location between the cores and moulds of this type is also very pronounced. It is obvious that new techniques around mould and core making have got to be used. The two immediate possibilities, those of shell moulding and CO_2 moulding, both of which produce a core or mould hardening *in situ*, are therefore very accurate in size besides being very handable and even capable of machining for accurate matching up. These have at the moment certain very pronounced difficulties, but the development in mould and core making that can be fixed while still in or on the mould, must be pushed urgently to a satisfactory conclusion. The present-day inaccuracies, not only in castings for the consumer goods, but also in the much heavier capital industry fields, are rapidly reaching a position which we can no longer put up with. In the aluminium foundries, there is no doubt that where the price of aluminium can be tolerated, the gravity method of casting must be replaced by the high pressure diecasting method. This unfortunately will mean that the aluminium casting industry will have to capitalise itself with modern equipment to a much greater extent than they are doing at the present time. It will also unfortunately mean that, because they will be producing a much more accurate aluminium casting, they will be selling far less aluminium. It is doubtful whether any real expansion in the use of aluminium will take place unless a very drastic reduction in the price of raw material is obtained. This reduction in cost must be somewhere in the region of 50 per cent of its present-day cost.

The forge, as we understand it today, is in comparison to the foundry a fairly modern industrial process. It is still within the memory of a large number of engineers that all steel parts were once machined all over, out of hand made forgings, so that the principle of producing what was thought to be an accurate steel component by hammering hot metal into a preformed die, is really, as far as engineering is concerned, a reasonably new process. The modern forge, however, has equipment in it, which has, relatively speaking, very crude standards of accuracy, which still uses very low levels of die accuracies, and which has practically no standard of pre-form techniques in order to really reduce the wastage of material in the forge.

It is possible that the forging industry, by use of spark erosion, and a new standard of capital equipment maintenance, such as we have in the machine shop, could put its house in order. Spark erosion, for instance, offers a means, once a master die is accepted as correct, whereby die maintenance and die wear could be controlled

Continued on next page

New Directions in Metalworking Practice

A survey by eight engineers on the growing points of metalworking practice. They report this week on—

* **Manufacturing Techniques of the Future** .. .. *by F. Griffiths*
* **Hydrostatic Drives for Machine Tools** .. .. .. *by D. Firth*

Over the next three weeks, the following articles will appear

* **Automation and Machine Tool Elements** .. .. *by F. Koenigsberger*
* **Numerically Controlled Machine Tools** .. .. .. *by R. C. Brewer*
* **Trends in Metal Removal** .. .. *by M. M. Barash*
* **Advanced Methods for Forming Metals** .. .. *by W. S. Hollis*
* **Machine Tool Rigidity and Vibration** .. .. .. *by H. Eddowes*
* **Machining at High Speed** .. .. *by R. N. Cook*

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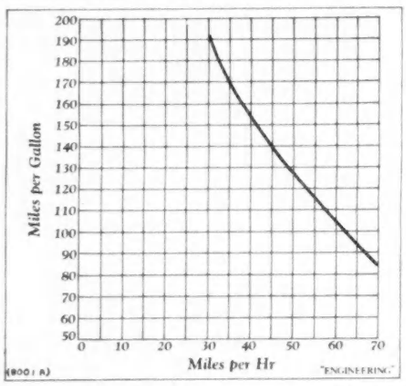

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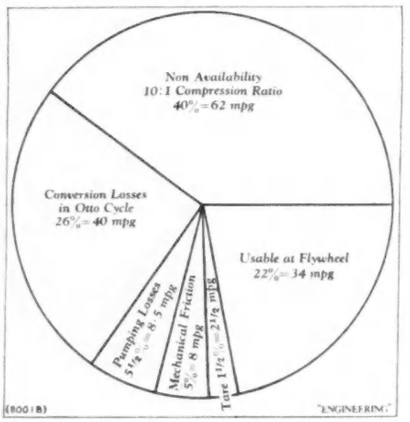

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Thus less than a quarter of the energy of the fuel is available at the flywheel. What likely improvement in engine economy can be expected? Losses in the Otto cycle cannot be recovered as long as that cycle is retained. If the compression ratio is raised, however, an improvement of about 8 per cent might ultimately be achieved, although fuel cost might offset the advantage gained. Incomplete combustion of the fuel is always likely to be present, and a 50 per cent improvement would only result in an overall improvement of 1 per cent. It is possible though. Then the effective specific heat of the gas might be improved with the use of weaker mixtures, as in stratification or Diesel cycles. About 8 per cent of the thermal efficiency might be recovered in this way by precombustion or fuel injection.

Improvements in engine structures have greatly increased the usable rate of pressure rise in the cylinder and further developments may lead to recovery of some of the losses due to delayed burning and heat loss to the coolant. Up to 5 per cent might be recovered.

Pumping losses could be reduced by use of an unthrottled air charge, the improvement varying with engine speed. At about 40 m.p.h., some 80 per cent of the total pumping loss might be recovered, and a gain in thermal efficiency of about 4 per cent seems possible. Improvements in lubrication, bore-stroke ratio, piston ring design, piston shape, may eventually give a 2 per cent better total thermal efficiency.

Finally, tare losses may be decreased by a more economical mechanism than the accelerator pump and by some method of optimum setting of the spark. About a 1 per cent gain in thermal efficiency might be expected.

Therefore in the future a saving of about 20 per cent in thermal efficiency might be achieved; this would then rise to 42 per cent, giving 65 m.p.g. in the absence of drive train losses and provided too many engine-driven gadgets are not added. Clearly, no single new invention or development is going to produce this figure. It will be the result of painstaking and gradual improvement in overall engine design.

Manufacturing Techniques of the Future

A considerable effort is needed to make the forging and casting processes more efficient in order that machining of components can be cut to a minimum.

By F. Griffiths

Chief Production Development Engineer, British Motor Corporation

It is proposed in dealing with the future trends in manufacturing techniques, to discuss those which will directly affect the very vast and growing consumer industries, and the effects that these new techniques will have upon the capital equipment industries which supply the means of production for the consumer industries.

The more remote techniques which are developing around such industries as those concerned with the manufacture of aeroplanes, missiles, and other things of a like type are, as yet, a long way from possible usage in the mass production industries.

When we look at the materials in common usage at the present time, other than plastics, and the production techniques which are used to fabricate these materials, we very soon realise that there has been no or very little fundamental change since the industrial era opened. For instance, the foundry, except when it is concerned with the smaller aluminium parts and a certain amount of iron which are produced from metal dies, has changed its fundamental techniques very little since it first became a unit of production. Certainly a small measure of mechanisation has taken place, but the casting normally produced has not improved in accuracy. The forge, although we have moved away from the anvil and sledge-hammer by using dies and mechanical hammers, is still an extremely crude process. The fundamental process employed in producing steel bar, is still thoroughly unorganised, with an end product of very crude dimensional accuracies, and with even cruder standards of finish. The use of metal in sheet form has produced a much higher standard of raw material, but still with the same appalling wastage that occurs in the other processes.

The sum total of these has been that a new highly expert industry has come into being centred around what is now called the machine shop. The capital equipment which is produced in the machine shop, solely for the purpose of sizing and finishing the products of the foundry the forge and the bar steel mill, is today of an extremely accurate and complicated nature, there having been an enormous degree of development and expertmanship engineered to produce the work that is required out of the machine shop. In fact, today, engineers are designing component parts, not around what is actually required of the component part, but around how it could be manufactured employing all this very expensive capital equipment that has arisen because of the crude basic components that are fed into it. It is obvious that the basic processes have been starved of the expert engineering which has gone into the machine shop. Not only are these processes in themselves crude, but the standard of the manufacture and maintenance of the tools and the plants are also of a very unsatisfactory nature. It is also obvious that it is extremely foolish to produce the great quantity of components that are required by the consumer industries, today and in the future, with these undeveloped basic processes. It is necessary for a very large effort by production engineers to move the concentration of engineering and capital from the machine shop into the basic processes, and the results of such action will be very important.

An improvement in the basic industries today could quite easily save far more money in the cost of the component parts than any action could possibly produce in the machine shop. Our processes and our thinking have been generated around a labour unit of cost, with capital and material cost being very much a second and third consideration. In the machine shop, mechanisation and automation have now reduced the labour unit of cost to such small proportions, that even quite a small saving in material or capital amortization could be of infinitely more value, and can be much more easily obtained, if we direct the emphasis of engineering skill along the right path.

The effect on the machine shop of any such action as an improvement in the basic processes could be very considerable. There is no doubt that one of the great problems in machine shop production for the consumer industry is the inconsistency of size and machineability of the component parts, as produced by the present methods in the basic processes. An improvement of this would facilitate production in the machine shop to an extent out of all proportion to the effort involved. Tool life could be immensely improved, far more than by improvement in the actual cutting materials that we use. The amount of capital involved in removing material would also be greatly reduced. In fact, the machine shop could be quite a small unit comprising mainly of sizing and finishing machinery. The cost of capital equipment for a given component would also be of very different proportions to what they are today, because much less would be required.

We will now consider, in relation to metals, what has to be altered in existing manufacturing techniques to obtain this, and what new techniques are likely to evolve in the near future.

In the cast iron foundry, at the present moment the techniques that are being used still depend to a very large extent on the operator's acquired skill. For instance, core making, no matter how mechanisation has been put around it, still involves the use of a human aptitude. The removal from the core box of moist sand with all the sagging possibilities before baking takes place is obviously capable of producing very great inaccuracies, and the use of green sand mouldings with all the rapping that occurs to get the pattern out of the mould also produces inaccuracies. The impossibility of accurate location between the cores and moulds of this type is also very pronounced. It is obvious that new techniques around mould and core making have got to be used. The two immediate possibilities, those of shell moulding and CO_2 moulding, both of which produce a core or mould hardening *in situ*, are therefore very accurate in size besides being very handable and even capable of machining for accurate matching up. These have at the moment certain very pronounced difficulties, but the development in mould and core making that can be fixed while still in or on the mould, must be pushed urgently to a satisfactory conclusion. The present-day inaccuracies, not only in castings for the consumer goods, but also in the much heavier capital industry fields, are rapidly reaching a position which we can no longer put up with. In the aluminium foundries, there is no doubt that where the price of aluminium can be tolerated, the gravity method of casting must be replaced by the high pressure diecasting method. This unfortunately will mean that the aluminium casting industry will have to capitalise itself with modern equipment to a much greater extent than they are doing at the present time. It will also unfortunately mean that, because they will be producing a much more accurate aluminium casting, they will be selling far less aluminium. It is doubtful whether any real expansion in the use of aluminium will take place unless a very drastic reduction in the price of raw material is obtained. This reduction in cost must be somewhere in the region of 50 per cent of its present-day cost.

The forge, as we understand it today, is in comparison to the foundry a fairly modern industrial process. It is still within the memory of a large number of engineers that all steel parts were once machined all over, out of hand made forgings, so that the principle of producing what was thought to be an accurate steel component by hammering hot metal into a preformed die, is really, as far as engineering is concerned, a reasonably new process. The modern forge, however, has equipment in it, which has, relatively speaking, very crude standards of accuracy, which still uses very low levels of die accuracies, and which has practically no standard of pre-form techniques in order to really reduce the wastage of material in the forge.

It is possible that the forging industry, by use of spark erosion, and a new standard of capital equipment maintenance, such as we have in the machine shop, could put its house in order. Spark erosion, for instance, offers a means, once a master die is accepted as correct, whereby die maintenance and die wear could be controlled

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New Directions in Metalworking Practice

A survey by eight engineers on the growing points of metalworking practice. They report this week on—

* **Manufacturing Techniques of the Future** .. .. *by F. Griffiths*
* **Hydrostatic Drives for Machine Tools** .. .. .. *by D. Firth*

Over the next three weeks, the following articles will appear

* **Automation and Machine Tool Elements** .. .. *by F. Koenigsberger*
* **Numerically Controlled Machine Tools** .. .. .. *by R. C. Brewer*
* **Trends in Metal Removal** .. .. *by M. M. Barash*
* **Advanced Methods for Forming Metals** .. .. *by W. S. Hollis*
* **Machine Tool Rigidity and Vibration** .. .. .. *by H. Eddowes*
* **Machining at High Speed** .. .. *by R. N. Cook*

to very close accuracies in terms of final component size, as well as in terms of long die life. It is possible that, providing some intelligent methods of holding and positioning the die in a hammer is used, a die can be taken out and re-sized by spark erosion before serious die deterioration takes place. The maintenance of hammers must be very much better than they are now, in order for the two halves of the die to be more accurately matched. One of the greatest complaints in all machine shops, when using the normal hot forging, are the numerous problems produced by the two halves of the die being inaccurately matched. A new method of annealing and normalising furnace design must evolve because again the problems caused in the machine shop by very inaccurate annealing and normalising in the forge cause immense cost in tool breakdown and consequent replacement. This variation is caused by the use of common furnaces into which various types of components, of different quantities and shapes, are often fed, with consequent difficulties in accurate temperature control. A much more accurate method of making pre-forms must be developed in the forge to prevent wastage and this will probably have to start somewhere as far back as the actual steel bar manufacture.

COLD FLOW FORMING

The above techniques and developments in the forge will have to take place if the hot forge, as we know it today, is going to withstand the challenge of cold flow forming and powdered metallurgy. Cold flow forming is rapidly moving into position, and some of the components being produced today are extremely interesting. The real problem with this technique is the manufacture of blanks and pre-forms, because any crude pre-form of the type that is normally produced in the hot forge, requires enormous pressures which in turn will involve considerable capital cost, and which must be resolved for this reason alone, without considering the very large saving that will be obtained by having no flash. The effects of cold flow forming, not only in metal saving but also in its effect on the machine shop, is such that the ordinary hot forge techniques will find it extremely difficult to compete. It appears that finished accuracies will be improved with cold forming, but at the present time industry is moving into cold forming mainly to save metal and metal removing.

Powdered metallurgy is a process which affords many interesting possibilities. The difficulty today is, in this country at any rate, that there is no unit with sufficient size of management and capital backing to do the development work required on a big enough scale. The general type of component which is being produced today, which is of the lower and middle classes of density and strength, is really only being played with, and there is practically nothing at all being worked out with the high density high strength materials which it is possible to use. The fact that in two directions, up and down, extreme accuracies are obtained, and the fact that a form of intermediate work can be done before the material is finally completely sintered, makes the whole process extremely interesting and an enormous challenge, particularly in regular shaped components, to the forge, the bar-maker, to the bar automatic industry and to the normal machine shop. At the present moment there seems to be an unnecessary amount of mystery wrapped around this process. The problem of the impact izod of powdered metallurgy is one that has got to be properly worked out and evaluated. There is a suspicion that the values accepted by the design engineer around the impact izod of normal materials need not necessarily apply to the components produced by powdered metallurgy. Powdered metallurgy, again like cold forming, has got itself into problems with capital equipment which must be worked out, so that it makes the process thoroughly economic.

The effect of these suggested alterations will be very considerable on the machine shop. It is obvious that the machinery which we use in the machine shop to rough a casting or forging or bar into its near final shape or size will no longer be required. It is highly probable that a lot of sizing and finishing off machinery will also not be required. Both cold flow forming and powdered metallurgy offer very exact methods of producing components to size. It is similarly obvious that such things as holes, either plain or tapped, will have to be produced from the solid, and will still require the normal type of machine shop equipment. This of course will be very seriously challenged by plastics.

The finishing and sizing processes which are now commonly used in the machine shop and which, to a very large extent, are based on grinding the material away with a compounded grinding wheel, must be very seriously looked at, because a process in which metal is scratched away by a more or less sharp piece of grit which disintegrates in the process and is replaced by another, is obviously fundamentally very crude, no matter to what degree of technical standard we have now developed it. The end result is that very expensive capital equipment has to be used to withstand the stresses which are inherent in the process.

The use of a process such as spark erosion and the like which carry no stresses whatever in them, would create the possibility of sizing and finishing with very cheap capital equipment.

The bar automatic, which produces components out of bar material, is one which must be seriously thought about in the not too distant future. A factory composed of bar automatics can quite easily produce twice as much waste material as it produces components.

This seems to be the general picture as regards the future trends in the metal fabricating, other than sheet metal, industries. The engineering and capital which is now put into the machine shop has got to be pushed back to the basic processes. The wastage of material now caused by these industries must be prevented, and the components made to a much more accurate size, so that the machine shop can be reduced to sizing and finishing equipment only. These sizing and finishing processes must be engineered so that the capital equipment involved costs very considerably less.

In the sheet metal industries at present steel is used, because it is cheap and we know how to work it. We also know how to work aluminium, but the cost here, just as in the foundry, must come down to about half its present price before it can challenge the position of steel. There is no doubt that in the consumer industries with their movement into greater production quantities, the press shop, which is equipped with general purpose type of plant, will have to be equipped with much more simplified in-line capital equipment, but it is questionable whether there is time to do this before steel in the consumer industry is replaced by straight injected plastics.

PLASTICS

The growth and development of the plastics industry has been one of the features of the post war years. It seems that the original plastics were developed around toys and very simple sorts of consumer goods of that type. In the last ten years, the industry has moved into home products and is now entering very much larger consumer industries, such as the motor-car and refrigerator industries, as well as into furniture and things of that nature. The development of plastics starting from nylon and then into poly-propylene, poly-carbonates and poly-formaldehyde, is moving into a new standard which, when in full production, will produce them at a price which will make the earlier plastics unsellable, and will make metals thoroughly uneconomical. A large number of parts for motor cars, refrigerators and other consumer items are now being made from these newer plastics. There is no doubt that in the next ten years more plastics will be born which will have even greater advantages to the engineer.

We are using metals today because they are cheap commodities and we know how to use them, and we are putting up with their weight and damageability because of these two dominating factors. The better types of plastics, as are mentioned above, and any others that will be developed in the future, will be cheap when compared with metals, very light, therefore very suitable for the consumer industries, and very un-damageable, which particularly in the motor-car, could offer very great advantages. The possibilities of using plastics in straight injection moulded components is very attractive, as there will be no waste material and very little subsequent operation. The tremendous impact that plastic foams, flexible, semi-rigid and rigid, is going to make on the consumer industry, is also one which is going to very seriously challenge the accepted position of rubber. The possibilities of moulding these plastic foams to their final shapes, and the future development of moulding fabricates to final shape, offer not only attractive costs, but very considerable variation in shapes and colours.

The techniques developing around the use of wood pulp are also extremely interesting, because this is a commodity which is basically extremely cheap and very plentiful. Quite a large number of parts which are either fabricated out of solid wood or out of steel can be replaced by the use of this material.

DIE MAKING

In surveying these new techniques and new standards which the consumer industry is moving into, it is seen that the attraction of all of them is not in the machine shop, but that the components will be produced accurately in the basic process, where the object will not only be to produce accurate components, to prevent the purchase of subsequent capital equipment to make them correct, but also save the enormous amount of waste material which takes place today. The dominating feature of this situation will be that the emphasis will move from the use of cutting mediums in tools and capital equipment to the problem of producing dies. It is obvious that the die manufacturing industry has kept its standards of accuracies around the processes to which they belong.

With new accuracies in the basic processes, particularly with cold flow forming, powdered metallurgy, and plastics, a new technique of producing dies must be developed. The problem with plastics will be even more pronounced than with metals, because these will demand a considerable number of matching dies with very narrow spaces between them. The time has come when these dies, rather than they be made by the very excellent skilled men that now make them, must be deliberately engineered from a department, particularly skilled in the techniques required. The work on the shop floor must be done accurately and automatically.

The medium of the punched tape or magnetic tape is the obvious solution. This has been done by certain groups, but unfortunately the electronic engineer, who does not understand the question of competitive costs, has become the prime mover in this work, and the process has been priced out of use. A new approach has taken place today in which the punched tape can be used as the medium between the engineering department and the shop floor for producing dies, and the piece of capital equipment that is to be put on the shop floor is of such a cost that it can be entertained by the normal die making industries. A new engineering service must be fabricated so that the normal die sinker can obtain the punched tape for any component which he may be making dies for. This is particularly necessary when dealing with shapes that are not engineered on the drawing board and for which detailed drawings are difficult to obtain. The problem of matching dies for plastics is one that is now being worked out.

The consumer industry also requires to move into automatic assembly and this presents a series of problems which will require a consider-

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Hydrostatic Drives for Machine Tools

Theoretically, the hydrostatic drive offers many advantages over both electrical and mechanical drives for machine tools. A vertical boring machine has been modified to hydrostatic operation to test the virtues of this method.

By D. Firth, A.M.I.Mech.E.

National Engineering Laboratory

IN MOMENTS of philosophic introspection the engineer is often entertained by the changes in engineering development caused by the application of old ideas to new problems. Many engineers of mature experience and not necessarily cynical as a result would agree, in this respect at least, with Ecclesiasticus that there is nothing new under the sun.

The inventive engineer is always working at the boundaries of knowledge and not infrequently his attempts to embody his inventions successfully are thwarted by lack of fundamental information, unsuitable materials and an unsympathetic reception by those who might profit most. Contrary to the scientist who is traditionally engaged in finding the answers to questions currently asked, the inventor is often producing answers to questions which do not yet exist. The idea is before its time.

Over the last half century there have been many demonstrations of this kind. A typical example is hydraulic power transmission. Hydraulic transmission falls into two groups; hydrokinetic and hydrostatic. The hydrokinetic converter invented by Föttinger at the beginning of this century and used, in a limited way, for ship transmissions up to and including the First World War has been re-discovered by the automobile industry. No motor car in the USA is complete without one.

Hydrostatic transmissions had a restricted application following their invention but a limited range of materials, unsuitable manufacturing and measuring techniques prevented their deployment for any but very special applications. It might also be said that industrial developments in other fields did not create an effective demand for this type of transmission.

Recent years have shown big changes. The virtues of the hydrostatic transmission have been rediscovered. Mainly because other industrial developments have created a demand for this type of solution to their problems. This is particularly true of the aircraft industry where hydrostatic machinery has been extensively developed. Another group whose development problems will be simplified by the use of suitable hydrostatic transmission is the heavy road vehicle and the earthmoving machinery industry. There is already much activity in this field.

The purpose of this article is to consider a further most-promising field of application by taking a brief look at the way hydrostaic transmissions might change, beneficially, some of the traditional aspects of machine tool design. To see, in short, how the new application of an old idea which has been extensively developed for other sections of industry might help machine-tool designers.

But first let us examine the characteristics of the modern hydrostatic transmission. A hydrostatic transmission comprises a hydraulic positive displacement pump and a positive displacement motor. Although they can be hydraulically connected back-to-back, remote and often flexible connections between the two offer substantial advantages to the designer. A remote flexible drive to a point distant from the electrical prime mover not requiring shafts, gears and constant velocity universal joints could take machine-tool design from one of its straight jackets.

SPEED RATIOS

The motor can be of quite different capacity from the pump, thus giving a " built-in " step up or step down speed ratio. Again, the pump or the motor or both can have variable capacity. Each combination has a different characteristic of speed ratio and torque ratio, but all stepless and variable and the choice would be determined by the nature of the application. The precise characteristic of each combination has been admirably described elsewhere by E. H. Bowers.[1]

It might be said that the advantages discussed so far are shared with electrical variable speed drives. Where the advantages of hydrostatic drives show in comparison with electrical drives is in reduced weight, and reduced overall dimensions for the same power. For instance, a hydraulic motor may be as low as one seventh of the weight of an equivalent electric motor with a commensurate reduction in physical dimension. An important consequence of this reduction in bulk is that a hydraulic motor can be reversed far more quickly than its electrical counterpart. The time constant of an electric motor has been shown to be at least four times greater than the equivalent hydraulic motor.[2] This is of particular importance where reversing applications are under consideration as in a planing machine. It is this feature which is responsible for the increasing use of hydraulic motors in the servo-loops of machine tool copying mechanisms; a side of the industry, incidentally, which is already benefitting from pioneer work in the field of aircraft hydraulics.

To this extent it can be said that hydrostatic transmissions are already being used in the machine-tool industry. The applications are usually low powered and are concerned with a comparatively small specialised section of the industry. Can they be applied advantageously to the main power drives on machine tools?

A common characteristic of machine tool drives is the stepped speed gearbox and the stepped down mechanism. When the choice of speed and feed is left to the operator, as is common in jobbing work, or in fact in any operation that is not automatically programmed, it is impossible to ensure that the best use is being made of the machine and the tool, particularly when the workpiece varies considerably in diameter. Manual changing of speed and feed is tedious and time wasting, particularly when the machine has to be stopped to change gear. In some gear heads the number of levers to be moved to make a single change in speed is formidable. This is particularly true of the change which has to be made in some cases when the back gear has to be engaged to get the next speed down in the range. When facing on a vertical boring machine, the gear changing necessary to keep a reasonable cutting speed presents an additional problem. Each stop to change gear leaves its mark on the surface being faced. Yet to keep a constant speed of rotation and let the cutting speed get lower and lower as the tool approaches the centre of the work produces a deterioration in surface finish which is equally unsatisfactory.

From every point of view, the economies of turning and facing work demands constant cutting speed automatically adjusted with changes in cutting tool radius. Within limits, this has already been done by electrical means. The apparatus necessary to achieve this is, however, bulky, heavy and expensive. In many cases they also require extensive control apparatus often employing electronics which, unfortunately, are still not as free from maintenance requirements of a specialised kind, as engineers desire. The main objection to electrics used in this way is that because they have to be connected to a machine tool which still requires a fixed speed reduction gearbox they add substantially to the cost of the machine tool.

BACKLASH AND WIND-UP

There are other disadvantages attached to gear drives in machine tools, particularly those which have to cope with intermittent cutting. Backlash and wind up cause a momentary hesitation at the onset of the cut and sudden acceleration when the tool is leaving the cut. Such effects are detrimental to tool life.

An ideal specification for a wide range of machine tools would be: constant cutting speed for changing diameter; elimination of gear changing while in the cut; the elimination of trains of gears and the use of a damped drive to ease the cutting shocks on the tool. This specification would be as true for an automatic

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Concluding **Manufacturing Techniques of the Future**

able effort on the part of the capital equipment supplying industries to work them out. Present efforts, particularly by the machine tool trade into automatic assembly are rediculous. The capital cost is beyond all sense. Automatic assembly means cheap standard indexing units, cheap standard units to take the place of hands, certain gadgetry, and an immense amount of magazining of the component parts. The capital equipment industry can obviously work out the first three, but the last one must be worked out by the consumer industry in cooperation with their suppliers.

The concept of the complete automation of the consumer industry is very possible, and highly probable. The movement into more accurate engineering will make automation immediately possible in the basic processes. The re-engineering of the finishing and sizing processes in the machine shop will also be capable of being automated. Automation in assembly, as has been shown, is also moving into line. The important feature then will be the automation of the relationship of all these processes and the feeding in of material.

There is one further trend in the consumer industries. The whole of the accounting and costing, which has been developed in these industries, has been developed around a unit of labour. This unit of labour, through mechanisation and now automation, is becoming, and has become, in many cases of a very small dimension. It has been found by the consumer industries that when doubling up output, even with a great reduction in the labour content, the price of the article is being increased. This is because of the cost and amortisation, etc., of the capital equipment. The mass producing consumer industries want fundamental basic capital equipment with no frills or fancies on it. If these are required by other industries, they shold be added afterwards. The consumer industries are moving into a position where the cost of the capital equipment is going to become the dominating feature, and not how much labour it will save.

machine with copying devices as it would be for a jobbing machine. With the programmed machine steplessly variable feed might be an additional requirement. An automatic change in feed when turning down a taper would be an advantage.

It has been argued that here is a prima facie case for a hydrostatic drive. To any group working on hydrostatic transmission it is an irresistible challenge. An attempt is therefore being made at the National Engineering Laboratory to find out whether the virtues of a hydrostatic drive can be exploited in this way.

"HYDROSTATIC" BORER

Because facing forms a high proportion of the working time of a boring mill, a machine of this type is being converted for the experiment. Because the machine is a conversion and not specifically designed around a hydrostatic transmission some anomalies have persisted. These include a flexible shaft drive from the tool-box traversing spindle to the cams controlling the displacement of the hydrostatic members. The basic hydrostatic elements are based on the NEL "ball" transmission for cheapness. Both pump and motor units are of the same design. The ball type of transmission is based on a radial design of cylinders where standard ball bearings are used as plungers. Pumping is produced by the balls moving in a race eccentric to the driving axis which is a pintle valve. Variable displacement is effected by simply moving the eccentric relative to the shaft centre.[3]

Fig. 1 shows a general arrangement of the boring mill. All the gearboxes and gearbox controls have been stripped out leaving the bare machine. Two hydraulic motors of identical design are being used and they drive the internal gear under the faceplate. Both motors operate from a common feed but in operation will have different displacements and a different head loss characteristic. Also driven from this gear rim is a small ball pump which then feeds a small hydraulic motor on the feed mechanism. The feed is thus tied to the rotation of the table. As with the main drive, the feed transmission is steplessly variable between 0·004 in to 0·25 in per revolution. By using some of the flow from the main drive pump, the feed motor can be used to give quick approach motions to the tool.

Because of their highly damped characteristic, it is hoped that the three units working directly on the face plate will alleviate tool shock on intermittent cutting.

Cams, operated by the motion of the tool automatically vary the displacements of the pump and motors to give constant cutting speed for changing diameter. An axial displacement of the cam gear sets the overall cutting speed. The range of speeds can be seen in Fig. 2. For instance, at a cutting speed of 400 ft per min constant cutting speed can be held from 16 in radius down to 3½ in radius and 200 ft per min down to 2 in radius. Fig. 3 shows the principle used in the main drive. The feed drive is not shown.

It would also be possible with this type of drive to give partial rotation and thus operate the boring mill as a planing machine for curved surfaces.

If satisfactory, this machine will demonstrate the simplification and the advantages to be derived from the use of hydrostatic transmission. A recent analysis[4] of the economics of stepless machine tool drives suggests that the extra amount of money justified for a stepless drive to a straight turning machine varies from about $1,000 to $2,500, the higher value for high speed steel tools and the lower for carbide tools.

When facing operations are included, this justified extra cost is estimated at $30,000 for high speed steel tooling, and $20,000 for carbide tools. These figures are estimated on the basis that the machines are operated under conditions to yield optimum machining cost per part. A machine specially built around a hydrostatic drive, by eliminating gearboxes, expensive and bulky electrical equipment, and by using an inexpensive design of hydrostatic transmission might offer substantial advantages over the conventional machine at competitive prices.

All this, time will prove or disprove. Even so, it is tempting to the engineer to imagine the effect that an economically successful application of hydrostatic transmission might have on machine tool design. A lathe, for instance, with a headstock manifestly designed for its bearings rather than the bulk needed for trains of gears or automatically operated clutches. The traverse mechanism operated not by a train of gears but by a small variable speed transmission which could also be used for quick approach. Gear trains would still be necessary for screw cutting. But most important, a lathe where constant cutting is maintained irrespective of the variation in diameter of the workpiece.

The possible changes to a vertical boring machine have been described, but it is not difficult to imagine how similar changes might benefit a horizontal boring machine. In this case, the limitations imposed by the belt drive would be avoided or, alternatively, the weight of an electric driving motor and gearbox would disappear.

REDUCED VIBRATION

Quite possibly traversing might be simplified by using a hydraulic motor on a rack. If a variable displacement were used in this connection both quick approach and traversing could be accomplished by the same machine.

Radial drilling machines could be freed from the weight of the driving motor and gearbox on the radius arm and, by presetting the maximum circuit pressure, a safe torque limit could be imposed when tapping.

There is already some evidence that grinding machines are improved by direct drive to the grinding wheel. Direct hydraulic drive to the workpiece on cam grinding might also help reduce the possibility of vibration caused by gear backlash, particularly when the grinding wheel is passing over the major axis of the cam.

The possibilities are considerable and too numerous to list in this article. In special purpose machinery, particularly automated machinery and copy machinery, hydrostatic drives are already in use. Their use in conventional machine tools would certainly alter their shape and performance.

Engineers often imagine the possibility of building up specialised machine tools from a number of basic components. With conventional drives all motions have to be connected by shafts and couplings, by bevelled gears where the shafts have got to turn corners and sometimes by worm and wheel. The problem also looms large of getting the necessary speed reduction box between the cutting head of the machine and the electric motor input. Although a certain amount of rationalisation has gone into machine tool design to make use of common gearboxes and the like, more flexibility is desired.

The future might show an increased movement in the direction of greater flexibility by an extended use of hydrostatic transmission. At the moment there is some reluctance to change because patterns exist and production lines have been laid down for the manufacture of gearing used in machine tools. Also, in the field of hydrostatic transmission the units made are, on the whole, general purpose machines and might need some redesign for machine tool work. It is more than likely that by going some way to meet each other by changes in design both the machine tool manufacturer and the makers of hydrostatic transmission will benefit.

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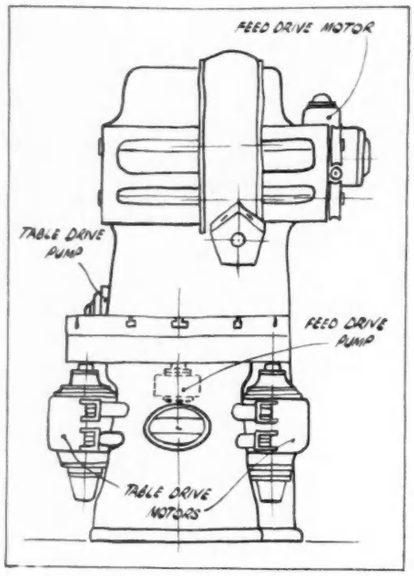

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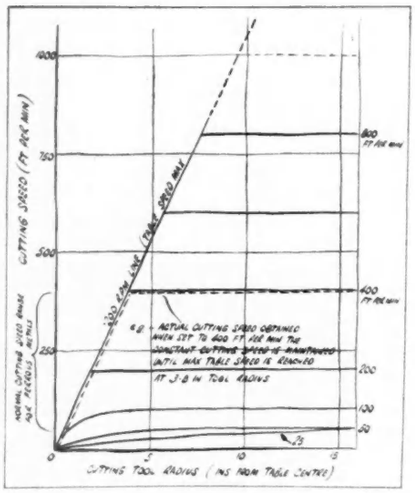

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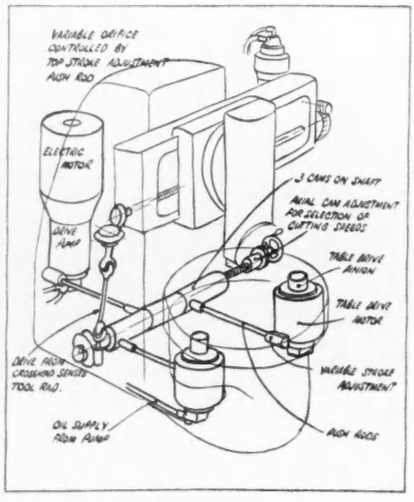

Fig. 3 The main drive of the boring mill.

Introducing Efficiency into Inspection

The true cost of inspection is seldom fully appreciated. Inspection efficiency can be improved by speeding up inspection techniques, by reducing gauge control time, and if possible by eliminating expensive gauges.

By P. A. McKeown, D.C.Ae.

Société Genevoise Limited

INSPECTION is still thought of by some managements as a necessary evil. Others think that if it is not let alone it might suddenly start producing more scrap! Even to the more logically-minded, who view inspection as a valuable control on the product, there is often considerable inertia to be overcome when the subject of reducing inspection time is mentioned, for it is widely held that the accurate measurement that is necessary, in gauge control for example, inevitably takes a long time. The metrologist will commend this attitude, for in principle it is true, but it is also true that certain measuring techniques are not only as accurate but also more rapid and reliable than others.

Measuring machines of the universal type, incorporating their own standards of length, have come into prominence in recent years, especially in gauge control cum standards room applications. They have become firmly established in the minds of those who are familiar with them, not as fault finders of unnecessary sensitivity, but as monitors on the accuracy and quality of the product. In opening up the field of very precise measurement to a far wider range of gauges and components than ever before, they have tended, to reduce in numbers those whose philosophy is that " tolerances are for amateurs," and also to enlighten those who are prone to use such expressions as " spot on."

GAUGING

Gauging has become an essential part of production. It has grown from the use of simple plug or caliper gauges, to the complex multi-dimensional air gauging systems that are used today in conjunction with large-batch and flow production. This does not mean, though, that gauges such as plug, caliper, taper, pin or screw thread gauges are obsolete. They are still, and will continue to be, widely used to control the manufacture of a very large number of component parts to close tolerances. This is especially true of " one off " and small batch production where automatic gauging, however technically efficient and desirable it may be for such reasons as the elimination of the human element, clearly cannot be an economic proposition.

Plainly these simple types of gauges cannot give measurements independent of the feel or manual dexterity of the operator, nor can they measure the size of a component. They are subject to wear and must, therefore, be tested periodically for accuracy. It is at this point that the accuracy, speed, reliability and overall efficiency of the universal type measuring machine has been most widely accepted in industry. Industrial metrology has benefitted directly from the continuous research achievements of scientific metrology. Only 50 to 60 years ago measurements of " half a tenth " precision were possible in a few research laboratories only. The measuring machine has made a large contribution towards making such precision now commonplace in the industrial field.

UNIVERSAL MEASURING MACHINES

The requirements of a universal measuring machine in order to make it both a good technical and a sound economic proposition may be summarised as follows. They are:

(*a*) Ease and speed of use,

(*b*) High measuring accuracy with complete reliability, and

(*c*) Low initial and upkeep costs.

In setting out to fulfil these requirements, the designer has, first of all, to choose the type of built-in standard of length he is going to use. He can choose between the following—a micrometer lead screw; an end-bar and/or slip gauge combination, probably used in conjunction with either micrometer screws or dial gauge indicators; a diffraction grating measuring system; or a precision scale.

Of these, the precision scale offers facilities and characteristics which are hard to beat. These include complete freedom from wear, and freedom from heating, stresses, the effects of dust and dirt, and from fear of either electrical or electronic faults.

The carriage of any machine incorporating a precision scale correctly mounted, can be moved even at high speed without introducing any of the possible causes of error listed above. But the first requirement of any standard is dimensional stability. Experience over 40 years has shown that this can be obtained from steel rigorously stress relieved. It is unfortunate that glass, the transparency of which makes possible simpler optical systems for scale reading devices, is unsatisfactory for scales longer than 8 in, since it has been found to have a dimensional stability as much as five or even ten times poorer than steel.

Advances in line standard metrology, such as the development of the photo-electric microscope, have increased the efficiency of production of precision scales and have raised their accuracies tremendously. Scales are currently produced for building into industrial measuring machines and machine tools, with accuracies of 0·00002 in over 20 in of length. They can be calibrated industrially with an accuracy of 0·000004 in (this is the maximum error between any two lines over the whole length of the scale).

After choosing the standard of length the next problem is how to use or how to mount it in order to minimise any loss of its inherent accuracy. It is not sufficient merely to have an accurate measuring system—it must be used correctly. It and the workpiece must move linearly, preferably (as first enunciated by Abbé) in line with the direction of measurement. In order to achieve this, it must be incorporated in what can be more aptly described as a machine rather than an instrument, in the sense of mass and rigidity. A well designed and correctly supported machine of high mass will ensure the minimum of elastic deformation and thus departure from linearity of movement. It will also offer the highest resistance to deformations caused by fluctuations in temperature. In addition, rigidity and robustness of design will inevitably lead to speed of use through confidence of the operator.

GAUGE CONTROL

One of a series of machines designed specifically for gauge control applications is shown in Fig. 1. They incorporate standard scales in a manner that enables all the usual types of gauges; plug, caliper, ring, taper and thread, to be readily standardised against them, without recourse to master setting pieces near in size to the gauges under measurement. To establish size in the majority of measurements only one reading is necessary from the micrometer microscopes used to view the standard scales.

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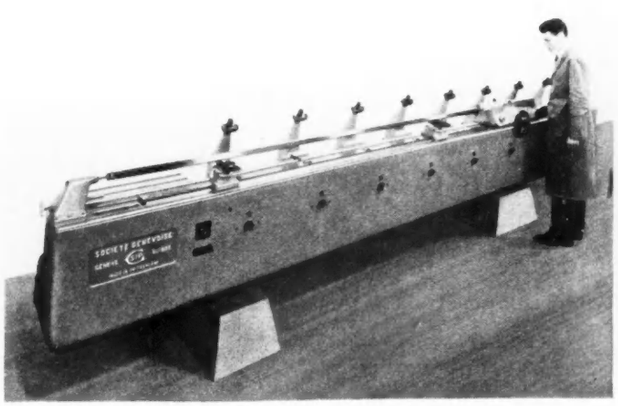

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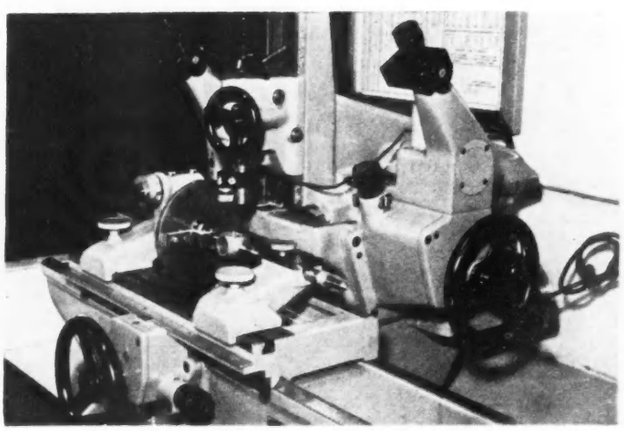

Fig. 2 The three coordinate type of universal measuring machine designed to meet the all-embracing requirements of the standards room.

machine with copying devices as it would be for a jobbing machine. With the programmed machine steplessly variable feed might be an additional requirement. An automatic change in feed when turning down a taper would be an advantage.

It has been argued that here is a prima facie case for a hydrostatic drive. To any group working on hydrostatic transmission it is an irresistible challenge. An attempt is therefore being made at the National Engineering Laboratory to find out whether the virtues of a hydrostatic drive can be exploited in this way.

"HYDROSTATIC" BORER

Because facing forms a high proportion of the working time of a boring mill, a machine of this type is being converted for the experiment. Because the machine is a conversion and not specifically designed around a hydrostatic transmission some anomalies have persisted. These include a flexible shaft drive from the tool-box traversing spindle to the cams controlling the displacement of the hydrostatic members. The basic hydrostatic elements are based on the NEL "ball" transmission for cheapness. Both pump and motor units are of the same design. The ball type of transmission is based on a radial design of cylinders where standard ball bearings are used as plungers. Pumping is produced by the balls moving in a race eccentric to the driving axis which is a pintle valve. Variable displacement is effected by simply moving the eccentric relative to the shaft centre.[3]

Fig. 1 shows a general arrangement of the boring mill. All the gearboxes and gearbox controls have been stripped out leaving the bare machine. Two hydraulic motors of identical design are being used and they drive the internal gear under the faceplate. Both motors operate from a common feed but in operation will have different displacements and a different head loss characteristic. Also driven from this gear rim is a small ball pump which then feeds a small hydraulic motor on the feed mechanism. The feed is thus tied to the rotation of the table. As with the main drive, the feed transmission is steplessly variable between 0·004 in to 0·25 in per revolution. By using some of the flow from the main drive pump, the feed motor can be used to give quick approach motions to the tool.

Because of their highly damped characteristic, it is hoped that the three units working directly on the face plate will alleviate tool shock on intermittent cutting.

Cams, operated by the motion of the tool automatically vary the displacements of the pump and motors to give constant cutting speed for changing diameter. An axial displacement of the cam gear sets the overall cutting speed. The range of speeds can be seen in Fig. 2. For instance, at a cutting speed of 400 ft per min constant cutting speed can be held from 16 in radius down to 3½ in radius and 200 ft per min down to 2 in radius. Fig. 3 shows the principle used in the main drive. The feed drive is not shown.

It would also be possible with this type of drive to give partial rotation and thus operate the boring mill as a planing machine for curved surfaces.

If satisfactory, this machine will demonstrate the simplification and the advantages to be derived from the use of hydrostatic transmission. A recent analysis[4] of the economics of stepless machine tool drives suggests that the extra amount of money justified for a stepless drive to a straight turning machine varies from about $1,000 to $2,500, the higher value for high speed steel tools and the lower for carbide tools.

When facing operations are included, this justified extra cost is estimated at $30,000 for high speed steel tooling, and $20,000 for carbide tools. These figures are estimated on the basis that the machines are operated under conditions to yield optimum machining cost per part. A machine specially built around a hydrostatic drive, by eliminating gearboxes, expensive and bulky electrical equipment, and by using an inexpensive design of hydrostatic transmission might offer substantial advantages over the conventional machine at competitive prices.

All this, time will prove or disprove. Even so, it is tempting to the engineer to imagine the effect that an economically successful application of hydrostatic transmission might have on machine tool design. A lathe, for instance, with a headstock manifestly designed for its bearings rather than the bulk needed for trains of gears or automatically operated clutches. The traverse mechanism operated not by a train of gears but by a small variable speed transmission which could also be used for quick approach. Gear trains would still be necessary for screw cutting. But most important, a lathe where constant cutting is maintained irrespective of the variation in diameter of the workpiece.

The possible changes to a vertical boring machine have been described, but it is not difficult to imagine how similar changes might benefit a horizontal boring machine. In this case, the limitations imposed by the belt drive would be avoided or, alternatively, the weight of an electric driving motor and gearbox would disappear.

REDUCED VIBRATION

Quite possibly traversing might be simplified by using a hydraulic motor on a rack. If a variable displacement were used in this connection both quick approach and traversing could be accomplished by the same machine.

Radial drilling machines could be freed from the weight of the driving motor and gearbox on the radius arm and by presetting the maximum circuit pressure, a safe torque limit could be imposed when tapping.

There is already some evidence that grinding machines are improved by direct drive to the grinding wheel. Direct hydraulic drive to the workpiece on cam grinding might also help reduce the possibility of vibration caused by gear backlash, particularly when the grinding wheel is passing over the major axis of the cam.

The possibilities are considerable and too numerous to list in this article. In special purpose machinery, particularly automated machinery and copy machinery, hydrostatic drives are already in use. Their use in conventional machine tools would certainly alter their shape and performance.

Engineers often imagine the possibility of building up specialised machine tools from a number of basic components. With conventional drives all motions have to be connected by shafts and couplings, by bevelled gears where the shafts have got to turn corners and sometimes by worm and wheel. The problem also looms large of getting the necessary speed reduction box between the cutting head of the machine and the electric motor input. Although a certain amount of rationalisation has gone into machine tool design to make use of common gearboxes and the like, more flexibility is desired.

The future might show an increased movement in the direction of greater flexibility by an extended use of hydrostatic transmission. At the moment there is some reluctance to change because patterns exist and production lines have been laid down for the manufacture of gearing used in machine tools. Also, in the field of hydrostatic transmission the units made are, on the whole, general purpose machines and might need some redesign for machine tool work. It is more than likely that by going some way to meet each other by changes in design both the machine tool manufacturer and the makers of hydrostatic transmission will benefit.

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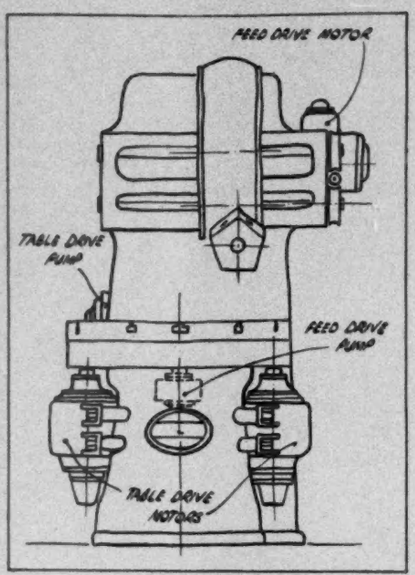

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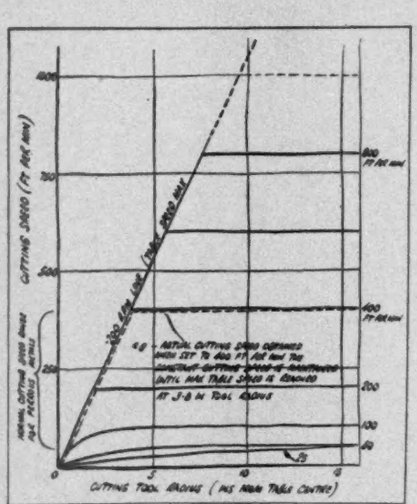

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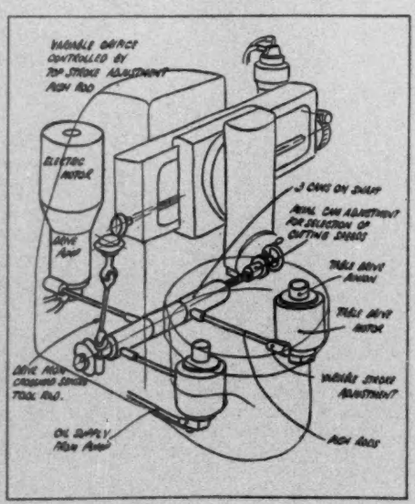

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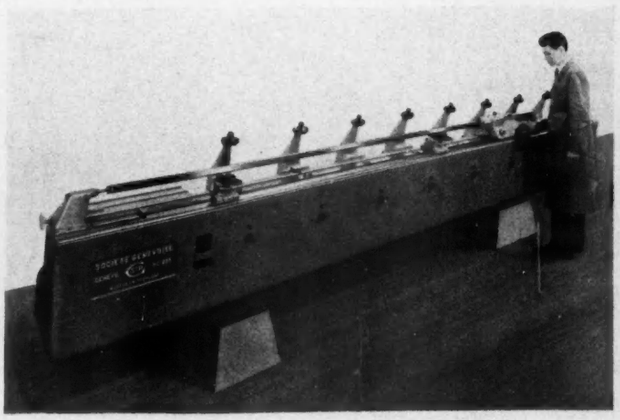

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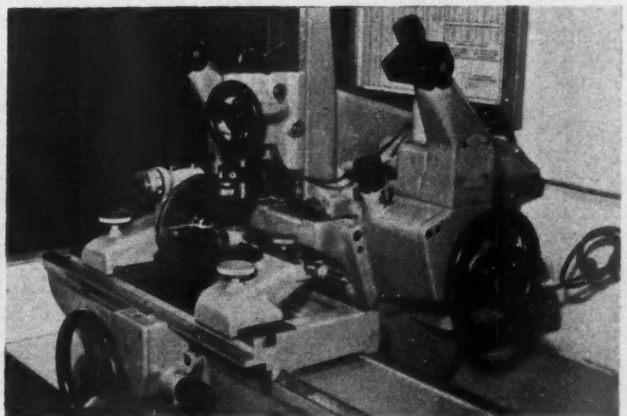


Fig. 2 The three coordinate type of universal measuring machine designed to meet the all-embracing requirements of the standards room.

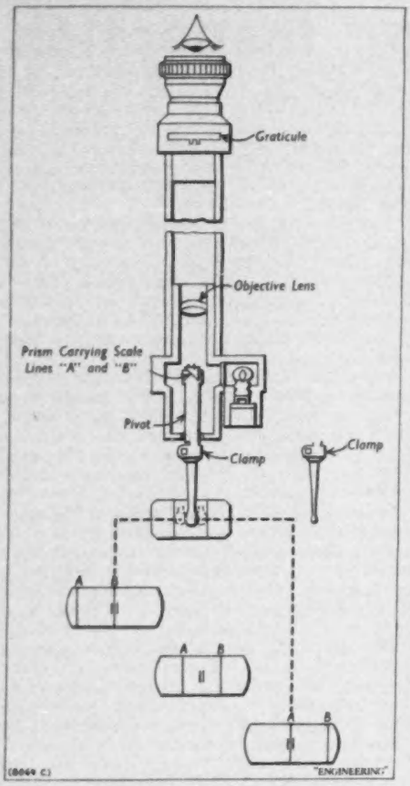


Fig. 3 Measurement of a gymbal part using the dividing head and fiducial indicator of the machine of Fig. 2.

parators, especially where slip pile combinations of more than two slips were consistently required. The corresponding gain for gap gauge measurement was found to be over 25 per cent.

An alternative method for measuring simple plug gauges is to use the conventional type of floating carriage diameter measuring machine. Here again, the universal measuring machine exhibits time savings. Its standard is built in. There is no need to select and place a master setting gauge between centres to zero the machine first, and then have only a 1 in total measuring range available before having to replace it with another setting master.

RAPID CHECKING

To facilitate rapid checking of parts, all of the same nominal diameter, all these machines contain built-in dial indicators of high precision. Having determined the size of the first of a batch of, say, 30 cylindrical components, by measurement against the standard scale, the following 29 are checked on the "clock" by comparison with the first. No great saving of time is offered in this case over the slip and clock method, except where the component is more easily and conveniently held on the machine than in the hand. For this reason alone, however, a higher measuring accuracy can be ensured.

The three coordinate type of universal measuring machine with its tremendous versatility widens the field of control to more complex gauges such as form profile and receiver gauges.

For speed considerations alone it is becoming more widely used in direct measurement of production components. In large batch and even mass production, it is often used to check the tool that produces the components; turbine blade forging dies, and follow on press tools for example. In this type of production, automatic gauging set-ups come into their own, but it is still necessary to establish the accuracy of their master setting pieces. The universal measuring machine is used here over a wide range, from master setting rings for air gauge bore measuring equipment through to the complete measurement of turbine blades. In batch inspection of a wide variety of component parts, which call for measuring accuracies easily attainable by "knife and fork" methods using conventional equipment (surface tables, slip gauges, height gauges, precision balls and rollers), for its speed of use alone the universal machine is becoming more widely used. Undoubtedly the increased accuracy of measurement and reliability it provides is also very welcome.

The component shown in Fig. 2 is not strictly a typical example, for it is regularly measured on the universal measuring machine for accuracy considerations as well as speed. It is part of the guidance system of a missile; it calls for the axes of the four bores to meet in a sphere of 0·00005 in radius. Parallelism and roundness of the bores must be held to 0·00003 in and the

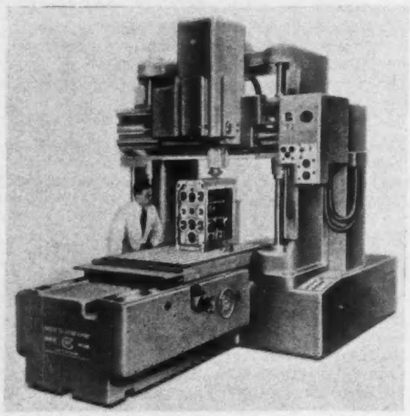


Fig. 4 The three coordinate, large capacity universal measuring machine which can be supplied with punched tape control.

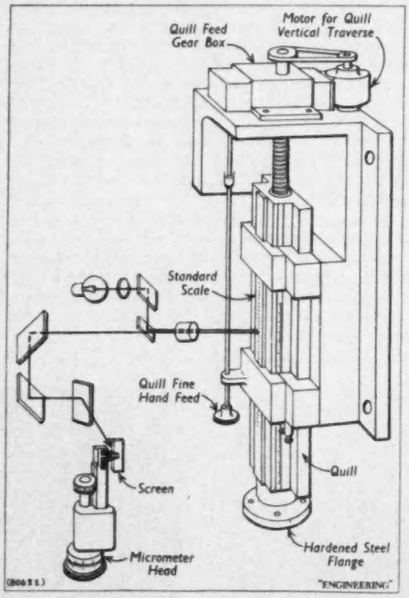


Fig. 5 The vertical slide measuring head mechanism of the machine illustrated above.

bearing housing diameters to 0·0002 in. The four locating faces must be flat and square to each other to within 0·0001 in over their total bearing areas. Wall thicknesses are tied up to close tolerances at specified positions. These components come through for measurement in batches of 25 to 30. Experience has shown that by comparison with traditional methods of measurement, the accuracies of which are doubtful, the universal measuring machine is five times faster. The measuring time on the universal measuring machine is approximately 2½ hours. It does not need any involved calculations to show that where one batch every three weeks is to pass through the inspection department the economy it offers is considerable.

It would be futile to claim speed advantages in all possible applications of such machines. Clearly there must be a "break even" point, on one side of which a machine with its possibly higher depreciation is not an economical proposition. The factors to be taken into account in such a calculation are the number of components in the batch, the frequency of the batches, complexity of the component, the accuracy of measurement required, the nature and cost of the appropriate automatic gauging system or alternative methods, the measuring time per component on all the possible systems, and the relative costs of the human skill required for each system.

It is precisely these factors plus the cost of programming, that must be weighed up in considering the economy of installing an automatically controlled universal measuring machine. Such a machine is shown in Fig. 4. It has been designed to accept workpieces up to 4,500 lb in weight and takes the form of the well-proven bridge type construction, utilised for the larger sizes of high precision jig boring machines. Here again, the opportunity arises to stress the rigidity requirements for such a universal measuring machine and show how they are achieved in order that the very heavy workpiece mounted upon the table, which itself weighs over 2,000 lb, can be displaced along the table's entire travel with the absolute minimum of deflection of the machine frame. The main base casting of the machine is a massive well-ribbed component. It is supported on three carefully positioned points to isolate it from the inevitable movements of the floor upon which it rests.

"Stiction" is a formidable enemy in the design of precision measuring equipment. On this machine the heavily-loaded work table moves on a system of cylindrical rollers which give an almost frictionless movement, regardless of load.

A very wide variety of measuring heads, some recording and some tracking with accurate rotation, can be accommodated interchangeably on the precision hardened steel flange (see Fig. 5) at the lower end of the vertical slide to suit the particular work under measurement. The measuring systems for the work table, measuring head saddle and vertical slide, are standard scales and projection reading screens.

AUTOMATIC CONTROL

A punched tape automatic control system can be supplied for the machine, controlling the work table, spindle head carriage, vertical slide and a precision circular table. Error of position of any one of these four movements is given by

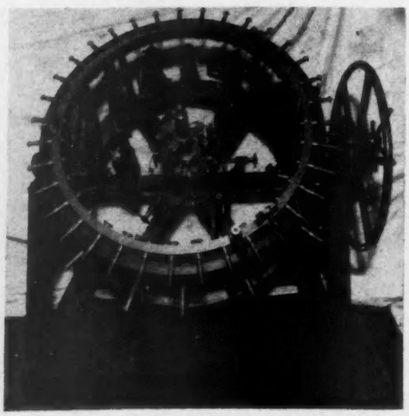


Fig. 6 The universal measuring machine eliminates the need for complex receiver gauges such as this.

Fully Automatic Heat Treatment

What is claimed to be Britain's first completely automatic heat treatment line for carburising, annealing, hardening and tempering has been installed by AEI-Birlec Limited at British Timken's Daventry East Works. The equipment has been built primarily for the heat treatment of tapered roller bearing cups and cones for vacuum brake rolling stock required under the railway modernisation scheme.

The processes, which are in automatic sequence, are performed in four Birlec furnaces—the furnaces being linked by mechanical and hydraulic handling devices designed by British Timken to meet their specific requirements.

Prior to heat treatment, cups and cones are stored in multiple units. From there they pass through a washing machine to the furnace operator's loading station. The components are loaded by hand on to locating fixtures manufactured from high grade cast nickel-chromium alloy. The loaded fixtures are assembled four at a time on nickel-chromium trays, three of which form a furnace charge at every loading sequence. Once the components are loaded on to the trays, their progress through the complete heat treatment cycle is automatic.

The continuous carburising furnace is heated by gas-fired radiant tubes arranged in four zones, each under independent and automatic temperature control. The first of these is a heating zone, the middle two are soaking zones, and the fourth is a diffusion zone. The total cycle time in the heating chamber is 24 hours, and the furnace has a capacity of approximately 500 lb per hour. A controlled carburising atmosphere is supplied to the furnace by an adjacent Birlec endothermic generating plant. Propane enrichment of the atmosphere is regulated by a Foxboro-Yoxall dewpoint controller.

The trayloads of bearing cups and cones that comprise a furnace charge are aligned along a triple track. They progress through the furnace by a sequence of synchronised pushes from hydraulic cylinder mechanisms located at the charge end of the furnace. While, at present, identical time cycles operate on the three tracks, appropriate sequence equipment has been incorporated to enable different time cycles to be used on the individual tracks.

The heating chamber is 31 ft 6 in in length and has a cross section measuring 6 ft 4 in wide by 1 ft 6 in high. Safety features have been provided so that, in the event of a power failure, the outer furnace doors rise automatically, and the furnace is shut down.

At the discharge end of the furnace, a further hydraulic pusher moves one tray at a time in sequence from the three tracks on to a platform. The platform is then lowered automatically into an oil tank to quench the charge. Next, the loaded tray is transferred by a motor-driven chain conveyor through a washing station. After passing through the two compartments of the station, one for spray wash and the other for a hot water rinse, the work tray is transferred automatically to the loading mechanism of the sub-critical annealing furnace.

The second furnace in the installation, for sub-critical annealing, is an electrically heated pusher type furnace. Rated at 145 kW, it is heated by wall-mounted tape elements arranged in three zones. Cups and cones are annealed in the furnace governed by the automatic cycle of the carburising furnace. An exothermic generating plant supplies a protective atmosphere to the heating chamber. After annealing the trays are discharged singly from the furnace and quenched, washed, rinsed and dried in a manner identical to that employed for carburising.

At this stage in the heat treatment cycle, the components are " de-stacked " from the tray and delivered to conveyors loading the hardening furnace. " De-stacking " is performed by two sets of air-operated fingers projecting from an overhead trolley. The stacks of cups and cones are lifted off the tray fixtures, and released in pairs on the conveyors. In the second stage of this operation, the turntable supporting the tray is rotated through 180°. The trays and fixtures thus emptied are returned to the charge end of the carburising furnace.

Bearing ring components after sub-critical annealing in the pusher furnace are transferred to a Birlec roller hearth furnace for hardening. The conveyors feeding the hardening furnace each carry forward a component which is deposited on the furnace track by a twin lever mechanism synchronised with the opening of the charging door.

The heating chamber, which measures 18 ft long internally is electrically heated by nickel chromium alloy tape elements in the roof and by cast grids in the hearth. There are two heating zones in the furnace, with a total rating of 120 kW, and each component completes the hardening cycle in approximately an hour. The furnace is provided with an atmosphere from an adjacent endothermic generating plant.

The rollers forming the hearth of the furnace are arranged in a number of sections. Each section is individually driven from a main shaft running longitudinally at one side of the furnace, just above floor level. At the discharge end of the furnace, the last section of rollers is fitted with an overdrive for fast discharge. Two photo-cell units control the operation of the fast roller drive gear and the discharge door. On completion of the necessary soaking time in the hardening furnace, the discharge door is opened to allow a pair of components, as detected by the photo-cell, to be discharged by the fast rollers. On emergence, the components are turned by deflecting ploughs through 45° to a pair of jig quench machines.

Pneumatic devices position the components against adjustable stops on the quench plates of these machines. Controlled quenches are then performed by the operation of air-hydraulic rams carrying jig plugs. These locate in the bores of the components during quenching and minimise distortion during the operation. A high rate of flow of quench oil is maintained for a predetermined period. The press ram then rises and the components are discharged along chutes and conveyors to a further washing machine.

After washing, cups and cones are aligned in a mechanised handling device which feeds the components across the width of a continuous tempering furnace. This device positions the cones inside the cups before entering the furnace.

Tempering, which is the final stage of the heat treatment operation, is carried out in a continuous slat conveyor furnace rated at 48 kW.

Components travel through the furnace on a series of steel slats supported by roller chains which engage sprockets at the ends of the frame. To promote convection heating, the slats are perforated and a vigorous air flow through the load is maintained by four roof-mounted fans. At the discharge end of this furnace, cups and cones are separated by another handling unit which so positions the components that they fall into two separate chutes. From these positions the components are fed on to two wire mesh belt conveyors to stacker storage units.

By the correct selection of quenching operations with this continuous installation of atmosphere furnaces, it has been possible to minimise the formation of scale on components during heat treatment. Indeed there is no necessity for any form of shot-blasting operation. Furthermore, by incorporating washing, rinsing and drying operations, degreasing has been avoided.

The supply of quenching oil to the three quenches in this installation, as well as to the roller heat treatment installation, is obtained from an oil service house where three 6,000 gallon capacity oil tanks and multiple pumping sets are situated. Thermostatically controlled Heenan and Froude coolers mounted on the roof maintain the correct oil temperature.

Throughout the whole of this installation and the roller heat treatment installation, the extraction of fumes and waste gases from the furnaces and washing machines has been afforded by a system of exhaust trunking supplied by the Modern Air Company of Leicester.

Concluding **Introducing Efficiency into Inspection**

a suitable locating device mounted on the vertical slide. Automatic retraction of the vertical slide (" z " ordinate) is a feature whereby during the setting of the " x " and " y " ordinates possible damage to the measuring head, due to collision with the workpiece, is avoided. Automatic clamping takes place at each position. The final positioning of any of the moving elements is controlled by a photoelectric microscope. As a direct measuring instrument in comparators for scale calibration work, the photoelectric microscope has been used with magnifications of up to 650,000 which enable great accuracy to be obtained with remarkable reliability (in the order of 0·01 millionths of an inch). The photoelectric microscope is used in this numerical control system as a servo device for final positioning of the measuring elements; it has a magnification of only 30 times which is still sufficient, however, to ensure repeatabilities to within 20 millionths. The displacement accuracy for the machine is 0·0002 in, for the entire travel of the work table, the spindle head saddle and the vertical slide. This figure again is to be understood as a tolerance, i.e. the peak to peak error, and not $\pm$ 0·0002 in.

The machine can be thought of as a completely universal receiver gauge. In the aero-engine industry where high precision is called for, there has been an increasing demand for such a universal measuring machine, not for gauge control purposes but for direct measurement of the many complex component parts.

RECEIVER GAUGES

The large and involved receiver gauge and marking-out fixture shown in Fig. 6 is typical of what is necessary to check certain large components for gas turbines; there are compound angles, compound curvatures, wall thicknesses, bore sizes and their positions to be carefully controlled. Where strength to weight ratio, high performance of the product, and interchangeability are so important, complex fixtures such as this are essential if no superior method can be found. Such a fixture would cost in the order of £1,500 and would handle perhaps a flow of ten components per month at peak production. The component for which this fixture was designed would take well over one man week of highly skilled inspection time. It has been calculated that on the large capacity three-coordinate measuring machine, the total inspection time for even a manually operated machine would be less than one complete man day. With as many as 12 other similar components for any one engine, all requiring jigs and receiver gauges of similar complexity and cost, it can readily be seen that the large capacity universal measuring machine cannot only pay for itself in a very short time but undoubtedly bring to bear a far greater accuracy of measurement on the component parts.

This is one of the latest developments in large scale metrology, which again is assisting industry to move not merely towards greater accuracy but towards greater overall efficiency through the reduction of inspection time, but with increased reliability.

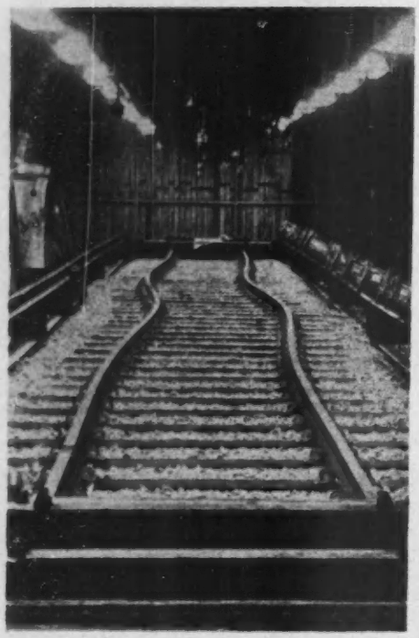
Benefits that Come from Welded Track

Longer track life, less maintenance and improved vehicle running result from long welded rails. British Railways have now adopted this type of track as a standard for important lines.

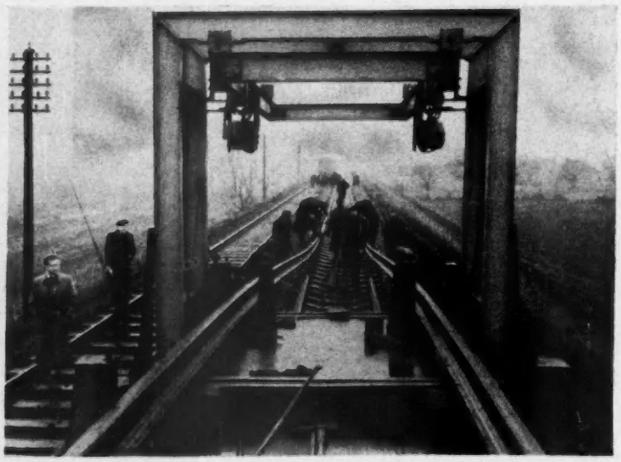
To the passenger, long welded rails mean only an improvement in travelling comfort; but to railway operators they offer, in addition, the important advantages of reduced maintenance, extended life of track materials, and less wear and tear on rolling stock.

The possibility of laying continuous rails has long been appreciated by British engineers, and experimental lengths were, in fact, laid on selected lengths of British Railways and London Transport lines before the war. After the war, London Transport adopted as standard continuous track half a mile long both in the tube sections and in the open.

But the use of long welded rails, though simple enough in principle, involves numerous changes in track design and track-laying techniques to meet the high standard of safety necessary and to ensure that there shall be a financial as well as a technical gain. British Railways therefore carried out a very detailed study of long welded track before deciding on its standardisation. As a result of this investigation it has been determined that, both technically and financially, long welded rails would be advantageous, and the use of such track is included as a feature of British Railways' modernisation plan.



(Left) The decision to use the long rails was based on extensive research. A buckling test is shown here.



(Right) New track laying methods are needed. Here the rails are being unloaded ready for laying, and being guided on to the baseplates.

The introduction of these new long rails is associated with the use of prestressed concrete sleepers, again for both technical and economic reasons. Concrete sleepers offer a much greater life and stability compared with timber. They cost more than timber, and have a negligible recovery value, but economically the concrete sleepers score on maintenance saving. New rail welding depots are being sited at strategic points in the various regions (some of them are already in operation), and the work of laying the new track has started. By the end of 1959 about 190 miles of track had been equipped with long rails, and when all the new depots are in full production, at least 320 miles of track will be equipped each year, each long rail section being over ¼ mile long.

The investigation into long welded rails was in three parts: (1) a series of field trials to gain information on the practical aspects of track laying, maintenance and welding methods, (2) field measurements of movements and temperatures, and (3) laboratory tests on the factors affecting long welded rail stability. From the field measurements it was confirmed that only the end 100 yards or so of a long welded rail move longitudinally owing to thermal stresses, and that the temperatures likely to be encountered ranged from about 8° F to 128° F.

STABILITY

Based on the site measurements, laboratory tests were devised to investigate the stability of long welded rails. A view of the rig, on completion of a test, is given in the left-hand illustration. The first of these tests was to determine the buckling characteristics. A track bed 120 ft long was equipped with a complete length of welded track, which could be heated by electric elements with parabolic reflectors. A compressive force of up to 75 tons per rail could be applied. With this rig the factors affecting buckling were investigated and note was taken of the effect of varying such things as type of rail, sleepers, ballast, fastenings and other possible variables. Ballast resistance was investigated, both laterally and longitudinally, by means of hydraulic rams and proving rings on a dummy length of track. Lateral stiffness and torsional resistance of track fastenings were similarly investigated, and both static and dynamic creep resistance were tested.

As a result of this work, involving over 120 buckling tests and the examination of some 47 fastening devices, a formula was derived for predicting the buckling load of any kind of track under any conditions. This formula for the buckling load, P, is

$$P = \frac{\pi^2 E I}{l^2} + \frac{\pi^2 C}{16 D}\sqrt{\frac{\pi l}{q}} + \frac{W l^2}{\pi^2 D q}$$

Where

- E = modulus of elasticity of steel rail
- I = moment of inertia of two rails
- l = length over which buckling occurs (taken for simplicity as 20 ft of flat bottomed track)
- q = maximum misalignment occurring in lengths
- C = torsional coefficient of fastening
- D = sleeper spacing
- W = lateral ballast resistance per sleeper.

Specifications have been drawn up for the long welded track based on the investigations, and for the rail welding depots. These latter are fully mechanised, and are equipped with straightening machines and AI electric welders. Rails can be welded in lengths of up to 720 ft, or later, up to 900 ft, and loaded on to trains for dispatch to the track laying sites.

INSTALLATION

Mechanised track lifting and relaying has been practised for some time, but new techniques are necessary to deal with the long welded rails. Machines running on the track or on an adjacent one are used to lift out complete 60 ft sections of timber-sleepered track, and as a temporary expedient, new sections of concrete-sleepered track are laid down by the machine complete with serviceable rails. These short rails are later replaced by long welded ones, which are paid out over the end of the train which brings them to the site. Apparatus has been devised to guide the rails on to the baseplates to which they will be fastened, as is shown in the second photograph. New track laying machines are being developed with greater capacity.

Good clean ballast is essential for long welded rail tracks, and specially designed ballast cleaning machines have been provided. For levelling the ballast a plough, hauled by a locomotive, is employed. This is used on the day of relaying. It is inserted into the ballast by lifting a track joint and is then drawn along in the ballast below the sleepers to ensure a uniform level.

After site installation the long welded rails are site-welded by one of two processes to form continuous lengths. Quick Thermit welding is employed in some cases and the Philips metallic arc process in others. With the quick Thermit process an oxy-propane or acetylene flame is used for preheating the rails prior to the actual welding. The Philips process requires no rail end preparation other than the setting of the correct gap and levelling and lining up.

If the continuous welded rail is laid in the track outside a temperature range of 55° F to 75° F the rails must be destressed when their temperature is within this range. To do this, all the rail fastenings are released, and an engine is run slowly over the track to assist the release of stress in the rails. The fastenings used with long welded rails have proved capable of preventing rail creep due to temperature changes, but British Railways practice is to provide adjustment switches on timber sleepers at the ends of continuous rails. These enable destressing to be carried out easily.

On the Shelf

By Frank H. Smith

THERE was a time when a book was written by an author. Came the time when he collaborated with another. Later still there were three or four authors and at last they had each chapter written by a different man (or two) and the whole appeared under the name of an editor. Now, with *Fracture* (Chapman and Hall, for Wiley) at 140*s*, I see we are up to four editors. Where do we go from here?

I do not know what the atomicists do with heavy water but I know what they do with their heavy literature. 402 pages of *Selected abstracts of Atomic Energy Project unclassified report literature in the field of radiation chemistry and bibliography of the published literature: 3rd annual supplement*, and that's only the title. A man named R. W. Clarke compiled it and I imagine he does little else. Probably never sees the light of a Berkshire day, poor devil. It must break his heart to see those 1,525 references (all indexed too) go for a mere 52*s* (HMSO). This third annual supp., by the way, only goes up to December, 1958, so it looks as though there's quite an untapped source of literature.

The British Ass., in their efforts to promote an interest among laymen in science, are making some changes in their journal *The Advancement of Science*. From May this year it became a six-times-a-yearly (as opposed to its present quarterliness) and will include, in addition to papers from the meetings, specially contributed articles, notes and comments on the current scene. Specimen titles are "The recent development of Greater London," "Defence against the sea" and "Problems of the Moon" (as though we hadn't enough of our own). 18 Adam Street, Adelphi, London, WC2, for further particulars.

The United Kingdom Atomic Energy Authority announces a greater use of microphotography through Micro Methods Limited (East Ardsley, Wakefield, Yorkshire). Reports which have hitherto been available only for loan will shortly obtainable from Micro Methods, and all unclassified and declassified reports issued between 1947 and 1956 will cost £120. January 1957 to June 1958 will cost £14 and July 1958 to June 1959, £9. Individual reports are available at 2*s* a go. A duplicated circular giving full details can be obtained (for nothing this time) from UKAEA, 11 Charles II Street, London, SW1.

Mr. Calvin Mooers, one of America's High Priests of Literature Coding, is over here to have a look at the Cranfield project (where they are trying out different methods of classification to see if any one is better than any other), and recently he gave a talk at Aslib on the "Tape-Typewriter Plan." This is a cooperative system for libraries and Aslib may have one or two copies left of the summary they sent out before his talk. It all looks a bit complicated to my simple mind and I'll bet it costs money anyway. I expect one of the Government departments will toy with it.

The European Productivity Agency (of OEEC, 3 rue André Pascal, Paris 16e) has devoted its No. 35 of *European Productivity* to less-developed areas and one might miss, therefore, an article in it by Alexander King (deputy director of EPA) on "Scientific and Technical Information from Russia." It is an introductory article to a free news-sheet *Russian Technical Literature*, which EPA is issuing.

Interscience Publishers evidently think that it is worthwhile having a special division to deal with textile books alone. Textile Book Publishers (88 Chancery Lane, WC2) announce the first fully definitive *Man-Made Textile Encyclopaedia*, to be published in the spring. There's a special prepublication price but the only one I can find is in dollars so you'd better try Chancery Lane. It is about time somebody invented a word for man-made fibres.

Metalworking Practice and Analysis

Production Tooling Equipment: The Design of Jigs, Tools and Gauges. By S. A. J. PARSONS. 2nd edition. *Cleaver-Hume Press.* (28*s*)

Tool Engineering. By S. E. RUSINOFF. *American Technical Society; The Technical Press, London.* (56*s*)

In the second edition of his book Mr. Parsons clearly demonstrates once more his recognition of the need, particularly by students, of a precise, clear cut work of reference on a subject more often than not sandwiched into rather more unwieldy volumes of a general production engineering nature.

This latest work again takes as its theme the design of jigs, tools and gauges, and introduces the reader briefly to production control, drawing office practice and, most important, the relationship between the product designer and the production engineer.

Mr. Parsons then continues with some fundamental ideas on drilling jigs and milling fixtures and a discussion of the classical "six degrees of freedom." This chapter is mainly concerned with the basic principles involved in the design of jigs and fixtures and provides a suitable "*entrée*" to the meat of the book, beginning in the third chapter with drill bushes and plates and followed by methods of clamping and locating.

Chapters five to nine deal in more detail with jigs, fixtures and milling operations, indexing jigs and fixtures and pneumatic and hydraulic devices, all adequately described and well illustrated, but it is unfortunate that there is no reference to jig borers as this is an indispensable facet of modern toolroom practice.

The underlying principles of stock removal are covered in the sections dealing with cutting tools and their materials and the use of diamond tools and ceramics receives good mention. In this edition, the author has added a section on the design, application and advantages of cemented-carbide "throw-away" tool tips of the multi-edge type, sufficient to arouse the readers interest, with a follow-up provided in the form of up-to-date references.

The section on machine tools devotes considerable space to the design of cams relative to single and multi-spindle automatics and advantage is also taken here to demonstrate the use of layout sheets. The economic aspects of tooling-up are considered and some brief observations on automation are made. The latter could perhaps have been dealt with in some greater detail in view of its increasing importance.

The book has clearly been designed as a quick and easy reference, and with its useful index and collection of detailed illustrations should prove to be a worthwhile companion in the production department.

In addition, the blessing of the Institution of Production Engineers is signified by the appendices containing typical syllabuses and examination questions for the Higher National Certificate in production engineering.

Professor Rusinoff's approach to this subject, however, is in a broader sense than that of the previous author, and those readers unfamiliar with American works of this kind could be easily misled by the title. The tool engineer is what we in this country would describe as a production engineer responsible for the overall manufacture of a product.

Statistical analysis is the theme running through the book, and the author illustrates his points in almost every chapter with examples, coupled with empirical formulae, which present a relatively straightforward solution to problems such as manufacturing costs, tool economy, cost estimation, economic processing and machine-tool replacement. Of particular interest are the examples demonstrating the Lehoczky formula for determining the most economic batch size for processing.

The sections dealing with tool design, locating and clamping cover, to a lesser degree, those items detailed in *Production Tooling Equipment*, but good use is made of photographs and illustrations, as indeed applies throughout the book, which is attractively presented and backed up with an excellent index.

Rarely do we find two books appearing at the same time as contemporary as these. Each grasps its subject firmly and wastes no time with irrelevancies. Such overlapping as occurs serves to better emphasise the importance and modern approach to the particular subject.

Both authors, in addition to holding academic posts, are well informed on current trends, particularly Professor Rusinoff who, as an industrial consultant, is well qualified to offer opinions on the solution of present day production problems.

C. H. HUDSON

Grinding and Gear Cutting Archives

History of the Grinding Machine. By ROBERT S. WOODBURY. (Technology Monographs Historical Series No. 2.) *The Technology Press, Massachusetts Institute of Technology, Cambridge 39, Mass.* ($3·50)

The history of grinding commences with the use of the simplest form of non-metallic tools known to man—tools for cutting, grinding and polishing, the operative part being usually of stone or flint. The use of grinding machines is, in general, applied to the three processes just mentioned. The French name for a grinding machine—*machine a rectifier*—has reference to its use for a finishing process. A very early process is the grinding of grain for food which is, in effect, cutting it into small pieces. A grinding wheel is essentially a cutting tool, or a multiplicity of cutting tools, held in such a way that they present cutting edges where required; in patent law grinding is looked upon as a cutting process.

Some important names are mentioned in the development of grinding machines, in particular Joseph R. Brown and Charles H. Norton, both of the Brown and Sharpe Company, Mr. Franklin B. Norton, of the Norton Company, and James J. Guest.

An interesting chart indicates the rapid progress in the use of abrasive materials in the United States between 1899 and 1930, the increase being in the region of 30 times. An illustration shows a grinding wheel from the library of the University of Leyden dated 850 A.D. Among early uses was the production and sharpening of knives and the polishing of armour. The grinding of lenses and mirrors for telescopes was quite an early application, and Leonardo da Vinci refers to the process as being used for grinding the edges of sheets of glass.

A number of materials have been developed in a form different from that generally found in nature including emery, corundum. silicon carbide and aluminium oxide; the use of diamond dust for grinding has long been in use and is still of importance. In the making of grinding wheels, the method of bonding grinding material in such a form as to be useful for its purpose has been widely studied, and for this purpose rubber is employed as well as silicate and plastic materials, while vitreous bonding is also well-known.

The early development of the precision grinding machine, as it is known at the present day, probably began about the middle of the 19th century in a relatively simple form. A ball

Continued on next page

grinding machine for making ball bearings was in operation about this time. A reference to Lucien Sharpe, of Brown and Sharpe, is given as 1948, but this should, no doubt, be 1848. A universal grinding machine which bears a striking resemblance to the present-day model was introduced by Brown and Sharpe in 1876. While modern grinding machines are usually precision tools, it is emphasised that an important feature is their ability to operate on hard materials.

Reference is made to the grading and grain size of grinding wheels and the various methods of dressing, truing and mounting are covered, including the crushing of grinding wheels as applied to screw-thread grinding and form grinding.

From being a finishing or polishing process, grinding has also developed into an important factor in economic production, as it can not only effect a rapid removal of metal but it can also save time in other machining processes. Interesting details are given regarding the development of centreless grinding and it is indicated that between 1920 and 1929 the rate of production of simple parts to which this method could be applied increased about 15 times, that is, about 1,400 per cent. The importance of balancing is mentioned; the use of lubricants and coolants has been a feature of grinding from the very earliest times.

A useful bibliography is given, covering the evolution of grinding both in America and in Europe. The book treats most aspects of cylindrical and surface grinding, but only a very brief reference is made to the subject of gear grinding; it does not go into details of the design or manufacture of machines.

History of the Gear-Cutting Machine. By ROBERT S. WOODBURY. (Technology Monographs Historical Series No. 1.) *The Technology Press, Massachusetts Institute of Technology, Cambridge 39, Mass.* ($3·00)

The development of various gear-cutting processes from the earliest days of their introduction to about 1910 provide the subject of this book. The author also makes brief reference to gear grinding and shaving, though without going into much detail in the case of these two processes.

The history is a very interesting one, particularly for students, but offers little idea of modern machines such as those in general use at the present day, for example, the many advanced types of gear tooth profile grinders and the latest gear hobbing machines. designed to give a high degree of accuracy and a high rate of production.

Reference is made to the mathematical analysis of gear tooth curves and the geometry of motion, combined with the rather empirical work done by clockmakers over a long period. The engineer appears to have developed the ideas put forward by mathematicians. Cycloidal gears have been contemplated since about 1450 and the earliest reference to involute gears is about 1690.

The application of gear cutting to heavy engineering dates from about 1800, and the introduction of the involute tooth corresponds roughly with the demand for interchangeability. Slight variations in centre distance could be permitted with an involute gear, which were not possible with other forms, and use was made of this property.

It is interesting to note that as early as 1700 a need was felt for improving the smoothness and quietness of operation, and the importance of uniform motion was recognised. It is pointed out that the making of accurate screws is closely allied with the problem of producing accurate gears. This comment applies right up to the present day. Controversies have arisen at different times as to the relative merits of different forms of tooth, and indeed more than once during the past 50 years. It is interesting to note that there was a similar controversy in England about 1800 which lasted for something like 30 years.

Many outstanding names are mentioned in connection with the development of gear-cutting machines, in particular, Robert Willis, George B. Grant, and Joseph Brown. An interesting wheel cutting machine is illustrated dated 1672, located in the Science Museum at South Kensington. (A similar machine is in possession of the Castle Museum at York.) It is interesting to note that the earliest machines only provided the means of indexing and of varying the depth of cut. Later additions were the introduction of a feed in the direction of the gear axis and a feed tangential to the axis.

The basic processes covered include: (*a*) form cutters having the same shape as the tooth space; (*b*) cutting with single-point tools guided either by a template or by suitable mechanism; and (*c*) generating processes based on a rack form or a circular-pinion type cutter derived from a rack form.

The introduction of the Fellows gear generator about 1899 brought in its train a machine for grinding the profiles of the cutters which was similar to some modern gear-tooth grinders. Reference is made to the hot rolling of gears which has recently been under investigation both in Europe and America. This was contemplated as early as 1872 by Comly, and by Anderson in 1910. The broaching of gear teeth which is sometimes regarded as a modern idea was carried out by Pohlem in 1729.

There appears to be an error in comparing the Reinecker spur-gear hobbing machine with that produced by Pfauter. It is stated that the Pfauter machine produced the change in which the cutter axis is no longer at 90° to the gear axis. The machine shown is dated 1897, but a machine by Reinecker dated 1894 is also illustrated which contains the same feature. The Reinecker machine was, in fact, a completely universal machine capable of cutting either spur, helical or worm gears. A differential mechanism was provided, and feed could be either in the direction of the work axis or in the direction of the cutter axis. The feature of the cutter axis not being at 90° to the gear axis is also clearly embodied in Grant's machine dated 1887, which is also illustrated.

Summarising briefly, the book is of historical interest to students but makes very little reference to developments since about 1910.

ARTHUR SYKES

Hot and Cold Divided

Industrial Thermal Insulation: Materials, Application, Methods, Specifications. By ALLEN C. WILSON. *McGraw-Hill, New York and London.* (70*s*)

Insulation is imperative in most forms of industrial apparatus. Waste of heating or cooling effect almost always means an unacceptable waste of money and although insulation usually saves far more than it ever costs, it is like any other ancillary—it costs least when it is intelligently used. The purpose of this book is to provide the background for its intelligent use.

Manufacturers of insulating materials have separately provided much information about their own products and their application, but the present book is an attempt to collect all the data together and to assess it independently. The book covers insulation applied to piping and to widely used industrial equipment. It covers the range of temperature between boiling point and 2,000° F, and there are a number of chapters devoted to the application of insulation to low-temperature work below the freezing point of water, particular emphasis being paid to the necessity for a satisfactory vapour barrier where rooms are to be used as cold stores and for piping carrying low-temperature cooling mediums. Three chapters deal with complete specifications for treating various problems—hot piping and equipment, low-temperature insulation on buildings, and low-temperature piping and equipment. These are eminently practical studies, illustrated with excellent diagrams.

Although the book is mainly practical in its approach, there is enough theoretical content to make it helpful as an introduction to technical students. Its main value, however, will be to practising heating, refrigerating and insulating engineers and contractors. Only passing mention is made of the application of insulation to air conditioning but the data in the book should be of some value to this branch of the engineering industry.

It should, perhaps, be emphasised that the book deals only with land installations. This is, perhaps understandable in an American author who is much less likely to have encountered the special insulation problems which are encountered in shipbuilding. The author has also deliberately excluded from his study the important subject of heat transfer through building materials on the grounds that adequate literature already exists on the subject.

The mathematics of heat transfer are not overstressed and derivation of formulae are not given, although footnote references direct the interested reader who wishes to investigate further the fundamental mathematical treatment of heat transfer to such well known authorities as McAdams, among others. The book is entirely concerned with practice followed in the United States, but this does not necessarily make the contents any less valuable to readers in the United Kingdom, and many of the insulation materials are available on this side of the Atlantic. Sufficient data for the economic selection of correct thickness and type is provided to enable the reader to carry out a proper comparison of various materials.

The book is profusely illustrated with diagrams, charts, graphs, and tables to reduce calculation to a minimum and to enable check selections and calculations to be speedily made.

An appendix gives definitions and terminology which would be invaluable for those commencing in this particular field. The appendix also contains heat loss tables for insulated 6 in diameter pipe and uninsulated pipe and other valuable data. The index is adequate.

J. M. BAXTER

Both Sides of the Outfall

River Pollution 1: Chemical Analysis. By LOUIS KLEIN. *Butterworths Scientific Publications.* (30*s*)

It is almost a century since the first Royal Commission on River Pollution was appointed in 1865. During this century most of the lowland rivers which pass through industrial areas have become steadily more polluted and, today, many estuaries are in a disgusting condition. It is, perhaps, unfortunate that, where a river or estuary is not used for a drinking-water supply, this gross pollution poses no public-health problems. One result of this is that, in place of a coherent advance in the control of river pollution based on a civilised policy of the "good neighbour," we have seen a series of *ad-hoc* improvements following the gadfly action of the Anglers' Cooperative Association. And one must admit

that, at the present time, it is chiefly the threat of a Common Law action that makes the recalcitrant polluter mend his ways. (Parenthetically it may be regretted that the recent Medical Research Council Memorandum No. 37 *Sewage Contamination of Bathing Beaches in England and Wales* is very likely to be taken by seaside authorities as a licence to continue to pollute our beaches and coastal waters.)

Recent years, however, have seen a stirring of public conscience, which, although it seems often to have left local authorities relatively unaffected, has had a very great effect on the attitude of industry. Today, it is safe to say that no large industrial polluter is unaware of the problem and most of them are honestly striving to do what they economically can to reduce their polluting wastes.

In England and Wales the River Boards and in Scotland the River Purification Boards are doing what they can to improve the quality of our streams and, in some areas, are achieving notable results. The Mersey River Board has as difficult an area in its charge as any board, but it is particularly fortunate in having Dr. Louis Klein as its chief chemist. Dr. Klein has had a long experience on both sides of the outfall—on a sewage-treatment plant and with a river board—and any book by him will, therefore, be opened with high expectations. Nor are we here disappointed.

In 1957 Butterworths Scientific Publications published Dr. Klein's *Aspects of River Pollution* which, at once, became the standard text on the subject. Dr. Klein has now revised, extended and reissued those chapters in the earlier book which dealt with the analysis of sewage, effluents and river waters.

In general the author does not set out to give detailed methods of analysis; such may easily be found elsewhere. He does what is, perhaps, even more important: he explains the reasons for the tests, discusses interferences which may be expected, and guides the reader in interpreting analyses, so that control measures may be intelligently based on them.

This book is more particularly addressed to chemists, but it cannot fail to be valuable to engineers also, and, if it has the effect of making engineers more conversant with and interested in the many facets of sewage chemistry, it will be doubly useful.

The first chapter which discusses the purpose of an analysis and the techniques of sampling could well have been even longer—for the engineer at least. Too often engineers imagine that in taking a sample in a clean bottle and getting it quickly to the analyst they have done their job. But even the most knowledgeable chemist cannot give the engineer data which the sample was not properly taken to provide. But this very slight criticism of the book is more than offset by the long last chapter on the significance and interpretation of chemical and physical tests. And the bibliography and appendices are worth almost the whole price of the book which is excellent.

PETER C. G. ISAAC

New Books

Tables of the Bivariate Normal Distribution Function and Related Functions. National Bureau of Standards Applied Mathematics Series, 50. *US Government Printing Office, Washington; HM Stationery Office, London.* (30*s* 6*d*)

A compilation and extension of various tables from Karl Pearson's *Tables for Statisticians and Biometricians*, H. H. Germond's *Miscellaneous Probability Tables* and other sources.

Études de Pyrométrie Pratique. By R. ALEGRÈ and others. *Éditions Eyrolles, 61 Boulevard Saint-Germain, Paris-Ve, France.* (3,300 *Frs*)

A collection of specialist contributions on the practice of pyrometry, covering the choice of method, and the use of thermistors, thermocouples, optical and photosensitive methods.

Residential and Commercial Air Conditioning. By CHARLES H. BURCKHARDT. *McGraw-Hill, New York and London.* (70*s*)

This is a " how-to-do-it " guide to the sizing, installation, and servicing of air conditioners, presenting the basic theory of refrigeration and air conditioning, followed by details of components and typical units.

Water Engineer's Handbook, 1960. Edited by D. WILKINSON and N. SQUIRE. 28th edition. *Colliery Guardian Company Limited, 30-1 Furnival Street, Holborn, London, EC4.* (20*s*)

A comprehensive buyers' guide forms an entirely new feature in this year's edition of the standard work of reference to the British Isles water undertakings.

A Source Book in Mathematics. By DAVID EUGENE SMITH. 2 Volumes. *Dover Publications, New York; Constable, London.* (28*s*)

An anthology of source material, divided into the fields of number, algebra, geometry, probability, and calculus, functions and quaternions. The first item is a selection from the first printed arithmetic, published at Treviso near Venice in 1478, and including the axiomatic proposition that " i times i maketh i."

Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy held in Geneva, September 1958. Volume 13, Reactor Physics and Economics. *United Nations, Geneva; HM Stationery Office, London.* (132*s*)

This volume begins with a section on the analysis of the economics of nuclear power, followed by papers on fuels and fuel cycles. In these two sections the key aspects of reactor economics are discussed, both with regard to such general problems as the re-enrichment of depleted fuel, and to the various promising reactor systems. The third section deals with neutron distribution and shielding.

Integrated Cost Control in the Office. By FRANK M. KNOX. *McGraw-Hill, New York and London.* (58*s*)

A volume in the US National Office Management Association series of monographs, prepared by the president of a company of management consultants specialising in the subject, and considering the place of work measurement and automation in the office.

Druckguss. By VINZENZ VON REIMER. *Carl Hanser Verlag, Kolbergerstrasse 22, München 27, Germany.* (38 *DM*)

An account of pressure die-casting equipment, materials and methods, intended for the use of engineers, designers, students and technical buyers.

Modern Aspects of Electrochemistry, No. 2. Edited by J. O'M. BOCKRIS. *Butterworths Scientific Publications.* (75*s*)

Contributors from Rostock, London, Auckland, Pennsylvania, Cambridge and Chicago have combined to produce a review of present knowledge in the fields of electrolytic solutions, ion-exchange resins, molten electrolytes, the anodic behaviour of metals, and the electrochemistry of the semiconductor-electrolyte interface.

Proceedings of the Fourth Midwestern Conference on Solid Mechanics, September, 1959. *The University of Texas, Austin, Texas.* ($12·50)

The development of nuclear and space applications of engineering have added to the importance of expanded research programmes in engineering mechanics, and the interchange of ideas and experience is fostered by this series of regional conferences. 29 papers.

Examples of the Design of Reinforced Concrete Buildings. By CHARLES E. REYNOLDS. Revised edition. *Concrete Publications Limited, 14 Dartmouth Street, London, SW1.* (12*s* 6*d*)

Revised in line with British Standard Codes of Practice for Reinforced Concrete, Nos. 114 (1957) and 3 (1952 amended 1958), the first part of this book covers loading and stress analysis, and methods of construction, while the second part is a study of the design of a typical multiple-storey building.

The Reviewers

Mr. C. H. Hudson, A.M.I.Mech.E., is assistant engineer, currently engaged on automation problems, with John Brown (Special Engineering and Nuclear Developments) Limited. He was lately with Capel and Company Limited, where he was responsible for the design and manufacture of small high-speed oil engines, and was previously project engineer with Davey, Paxman and Company Limited.

Mr. Arthur Sykes, O.B.E., B.Sc., Wh.Ex., M.I.Mech.E., M.I.Prod.E., M.S.A.E., is technical director of David Brown & Sons (Huddersfield) Ltd.

Mr. J. M. Baxter is air conditioning plant designer with Thermotank Limited.

Mr. Peter C. G. Isaac, B.Sc. (Eng.), S.M., M.I.C.E., M.I.W.E., M.Inst.S.P., F.R.S.H., is senior lecturer in public health engineering at King's College, Newcastle, in the University of Durham. He is the author of *Public Health Engineering* and editor of *The Treatment of Trade-Waste Waters and the Prevention of River Pollution* and *Waste Treatment*.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Plant and Equipment

Distillation Plant. G. AND J. WEIR LTD., Cathcart, Glasgow, S4. Sea water distillation plant, multi-flash process. Two brochures give diagrams and particulars.

Office Supplies. OFFICE EQUIPMENT CO., 113 High Holborn, London, WC1. Catalogue of office furniture and equipment including desks, chairs, heaters, typewriters, and kettles.

Radiant Jet Furnaces. INCANDESCENT HEAT CO. LTD., Cornwall Road, Smethick, Birmingham. Batch furnaces using Jetube radiant heating elements for all general work and controlled atmospheres in the range 700 to 1,000° C. Two standard sizes: leaflet V61 gives details.

Document Copier. SKYCOPIES LTD., 75 Southwark Street, London, SE1. Skycopy document copying machines for black and white or colour work. Several models. Leaflets.

Bag Packer. THOMAS ROBINSON AND SON LTD., Rochdale. High speed bag packer and sewer with integral weigher, type HWPa. Will handle eight 70 lb bags per minute. Folder.

Xerox Copying. RANK-XEROX LTD., 33-41 Mortimer Street, London, W1. Automatic Xerography for copying work. Types and scope described in booklet and leaflets.

Bright Annealing. METALECTRIC FURNACES LTD., Cornwall Road, Smethwick 40, Staffs. Equipment for continuous bright annealing is described in folder M6A.

Pressure Vessels. HADFIELDS LTD.; East Hecla Works, Sheffield 9. Any size of pressure vessel made of forgings, castings or fabrication. Brochure gives examples and uses of each type of construction.

Ovens and Furnaces. HEDIN LTD., Commerce Estate, South Woodford, London, E18. New catalogue covering ovens, furnaces, and heating elements as well as laboratory equipment, is now available.

Fixtures. WOODSIDE DIE SINKING CO. LTD., Aire Vale Works, Newlay, Leeds 13. Tooling aids for jigs and fixtures made up of standard items. Leaflet.

Office Furniture. EDGLEYS LTD., 151 Fleet Street, London, WC4. " Uniplan " items for complete office furnishings; desks, tables chairs and cupboards. Folder.

Marketing

Road Tolls and Red Herrings

AT A time when yearly spending on new roads is only £75 million in a total budget of over £5,000 million, talk of tolls on motorway use is nothing more than a red herring attempt to excuse failure to produce a full scale road programme.

The June bulletin of the BRITISH ROAD FEDERATION making this caustic comment reflects with some anguish that no less than £600 million of that budget was raised by motor taxation. R. A. Butler, now Home Secretary, looked forward some years ago to the doubling of the standards of living over 25 years. There has never been any very clear idea how this was to be measured but the BRF point out that if it does come about then there will be a substantial increase in the savings that can be applied to capital investment.

While the gap between revenue from road users and investment in new roads goes on growing it is economically absurd to propose adding to the burden on industry of bad roads a financial penalty for using what few special roads are provided.

High Level of Tool Exports by David Brown

The DAVID BROWN Machine Tool Division, at Manchester, has received a significant order from Czechoslovakia. The machine tools, worth £80,000, are for the production of transmission components in a commercial vehicle factory.

Half as high again as the average export figure for the machine tool industry, the division reports that four fifths of its high grade gear cutting plant production is going overseas.

Greek Sulphuric Acid Plant Order

A contract for a 376 metric tons a day sulphuric acid plant to be built in Northern Greece has been placed with CHEMICAL CONSTRUCTION (G.B.).

The design, supervision of construction and responsibility for initial operation of the plant are all covered by the agreement. The plant will be part of a major nitrogenous fertiliser works.

Cranes in Tandem at Scotstoun

A mighty lift has been in use at the Scotstoun, Glasgow, shipyard of CHARLES CONNELL and Company where they are building a 37,000 ton tanker. The two travelling cranes, one of 60 tons lift and one of 40, have been linked by a beam and used to lift two boilers, each with a shipping weight of 84 tons.

The BABCOCK & WILCOX boilers, made nearby at the BARCLAY, CURLE Company, were lifted from a barge on the Clyde and placed on the boiler flat. The tanker is the largest ship yet built at the yard which is now equipped for building vessels up to 65,000 tons. She is for the CHARTER SHIPPING COMPANY OF BERMUDA.

Subsidised Consultants for Equipment Exports

In some parts of the world it is as good as impossible for a consulting engineer or mining geologist to practise if he is not subsidised. Nearly all competing foreign consultants are able, by one method or another, to quote a subsidised fee where this is of use either to national political strategy or to their countries' mining machinery makers.

These points were made at a recent meeting called by the BRITISH MINING EQUIPMENT EXPORT ASSOCIATION by Mr. C. R. C. Burton, a director of INTERNATIONAL COMBUSTION (EXPORT).

Mr. Burton declared that there is a comparative scarcity of British mining consultants abroad, because they were almost alone in having to quote economic fees on work connected with foreign aid programmes. Nearly all their competitors were able to quote subsidised fees. The facilities for British consultants to be so subsidised, whether by Government, financial institutions or the mining machinery industry at present are almost non-existent.

There appears to be a case here to assist British consultants to quote economic fees. The logical development may be that consultants from the United Kingdom will end up in the position of being the only advisers from whom a foreign Government can obtain advice which is not qualified by some special interest.

The BMEEA, one year old next month, was formed to tackle problems relating to the industry and the Government or the various financial agencies at home and abroad, and to further collective market intelligence and sales promotion.

A principal factor in bringing the association was the fierce competition from many other countries, especially the United States, Germany, the Soviet Union, France and Japan.

British mining machinery manufacturers have become much more dependent for expansion and even maintenance of sales upon the overseas markets. The NATIONAL COAL BOARD has both cut down orders and decided upon a smaller expansion of its industry.

At the same time as the contraction at home and the intensification of foreign competition many of the customary overseas markets have themselves become self-supporting or have turned to other suppliers.

Mining Expansion

The underlying position is an encouraging one, whatever the short term factors. Rising populations and living standards must mean the expansion of mining activities. Two years ago a meeting of mining economists thought that investment in mining machinery of £2,000 million a year would be needed to meet the increase in mineral consumption due to these two main causes.

In addition to this would be the capital investment wanted for new mining capacity and replacements to maintain present output.

Given this background it is as Mr. Burton said, highly pertinent to inquire why the United Kingdom mining machinery maker is not selling abroad a quantity of plant equal to the reputation of the products and the capacity of the industry. More than 450 companies are currently exporting mining and ancillary equipment at an annual rate of £40 million.

Much of the overseas opportunity for mining equipment exists in developing countries who need outside financial help and technical aid.

The first of Mr. Burton's three reasons for the present situation was the absence of continuing and constructive liaison with Whitehall, the City and the agencies of foreign aid. There is an urgent need for the British mining manufacturing industry to establish a close liaison with Whitehall, the financial institutions of the City and with other groups upon whom depend the creation of new export sales opportunities.

With overseas mining markets spread through more than a hundred countries the cost of export sales promotion and service maintenance can be prohibitively high. It is here that the Export Association has a major part to play.

Ville d'Anjou Refinery Coming "On Stream"

The BRITISH PETROLEUM Company's first refinery in North America, at Ville d'Anjou, Canada, is now complete and is to go into service, or in refinery parlance, come "on stream", within the next few weeks.

It is two years since the ground breaking ceremony on the 600 acre site, which is now a third covered with the refinery's tanks and processing equipment. To be operated by BP REFINERY CANADA Limited, the plant is to process 25,000 barrels a day of crude oil.

Pipelines play a big part in bringing crude oil to the refinery and in taking away refined products. Crude can be brought in through the Portland (Maine) to Montreal pipeline, in which BP have bought a 10 per cent interest. Or through the three mile pipe from the new 780 ft wharf built on the St. Lawrence river for BP by the Canadian National Harbours Board.

Distribution of the refined products will be through the Trans-Northern pipeline, by road, rail and by river.

The processing plant includes a crude distillation unit with atmospheric and vacuum sections, a distillate treater, a catalytic reformer, and catalytic cracking unit with associated catalytic polymerisation unit. The refinery's waste gases will be sold for petroleum chemicals production.

Innovations by the Million in China's Industry

Taken at their face value, the statements of a Chinese Deputy Prime Minister, Mr. Po I-Po, suggest that channels have been found for the technical inventiveness of very large numbers of people indeed.

Mr. I-Po, writing in the Communist Party journal *Red Flag*, says that "millions of innovations" are coming forward from ordinary workers and peasants. More specifically he also says that labour productivity in the first quarter of this year was 85 per cent higher than in the same months of 1959.

This does not imply that large numbers of people were taking it easy last year, or that some new methods of measuring have since been adopted. It is more likely to be a reflection of attention being paid to mechanising heavy manual labour and many hand operations that left the industrial scene in the West and, for that matter, Russia, long ago.

Mr. I-Po writes that the majority of industrial enterprises now have spare-time technical classes and that a number have scientific research institutes.

Britannia Goes to Aid Chileans

A Britannia aircraft of RAF Transport Command accompanying the Secretary of State for Air on a goodwill visit to South America, was used last month to take supplies at short notice to disaster areas of Chile.

The British hospital in Buenos Aires, the Argentine Red Cross and British and Argentinian firms in the city gave drugs, medical supplies, emergency foods and clothing which were carried to the refugees by the Britannia.

BMC Bathgate Turnover to be £50 Million a Year

A start to production in 18 months time and full production two years from now is the BRITISH MOTOR CORPORATION'S plan for the £11 million truck, engine and tractor plants at Bathgate, outside Glasgow.

The BMC deputy chairman and managing director, Mr. George W. Harriman, has announced that not less than half of the expected annual turnover of £50 million would be exported. The Corporation has already laid its plans for doubling the capacity of the works within a few years.

Mr. Harriman explained that it is his view that the under-developed countries are more keen on roads than on railways. It followed from this that they first of all wanted tractors to help in road building and they then needed heavy commercial vehicles on the roads.

BMC output of trucks of more than two tons will increase from the present 850 a week to 2,000, diesel engine production will increase to up to 1,500 a week in the early stages of the scheme. The Corporation's tractor turnover is to be raised from 250 a week to 750 and some implements may also be made.

An 80-hr Week

Six million pounds will be spent on plant and machinery for the 1·25 million sq. ft factory. The operations plan is based on an 80-hour week. From an initial employment of 6,000 it is expected that eventually 10,000 people will be working at Bathgate.

Up to 300 of the Midlands staff will transfer to Bathgate to see to it that there is continuity of Austin and Morris methods.

For Scotland the BMC activities at Bathgate are in a sense just the visible part of the iceberg. Beneath the surface is a development in component manufacturing, among existing firms and by the expansion to within reach of Bathgate of BMC's existing parts suppliers. Beyond these again is the further expansion of sub-contracting works, service facilities and the general economic effect of the BMC's eventual 10,000 weekly pay packets.

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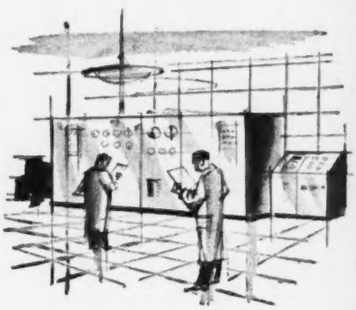

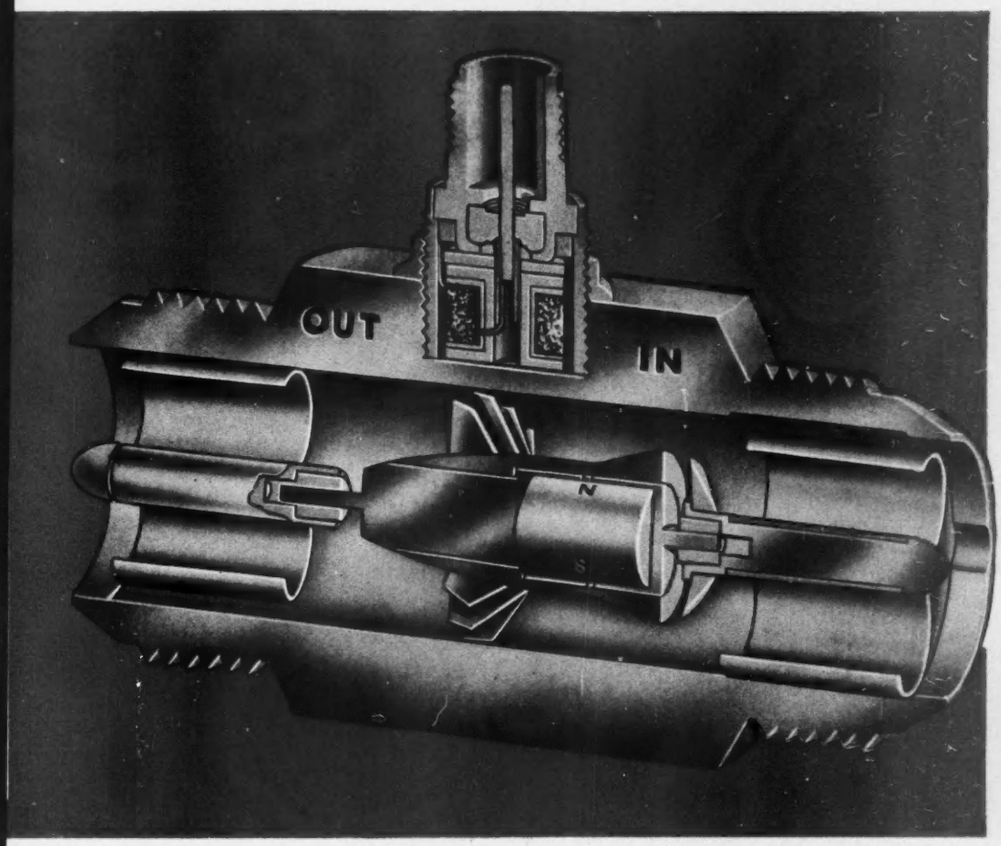

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- Contains only one moving part—no thrust bearings—operates with a minimum of maintenance at high temperatures and pressures.
- No larger than the pipeline in which it is installed—may be mounted in any attitude.
- Can be supplied with indicating, recording and process control equipment—gives digital presentation of results.
- Can measure volumetric or mass flows.
- Models available to measure flows from 0·1 to 40,000 Imperial gallons per minute, at a wide range of operating pressures. Larger and smaller sizes made to order.
- Can measure flow of any liquid or gas, irrespective of its lubricating or non-lubricating properties, at temperatures ranging from -455°F to 1500°F.
- Manufactured as standard in stainless steel—can be made in any non-magnetic material.
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Ball Clutches Have No Backlash

The time may come when ball clutches will be as common among machine elements as gears, bearings and levers. Originally not much more than a sophisticated alternative to the ratchet, ball clutches have progressed a long way since and are now used in such machines as dissimilar as desk calculators and earth moving equipment.

Three principal applications may be distinguished: freewheeling, reverse locking, and transmission-train switching. All three could be performed by ratchets, but ball clutches show superior qualities in each. Fig. 1 shows the internal arrangement of the basic design; the spring-loaded balls wedge into the decreasing space between inner and outer race on reversal of rotation. A ball clutch will lock almost instantly without appreciable backlash as soon as rotation is reversed. Built with the precision of ball bearings, the load is evenly distributed and the capacity of the clutch is greatly increased. Standard designs for 2 to 12,000 ft-lb torque are available in the Stieber Rollkupplung range, and for special applications units with 180,000 ft-lb maximum rating have been built. The latter are employed in conveyors designed for loading ships in an American harbour and two of them are shown in Fig. 3.

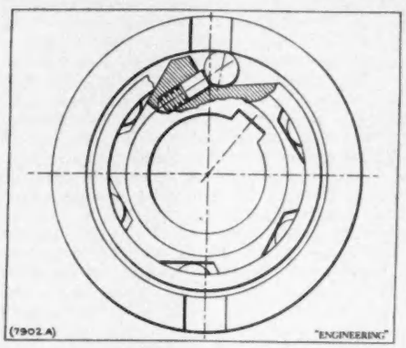


Fig. 1 Schematic arrangement of basic ball-clutch.

For applications with shaft speeds up to 30,000 r.p.m. a special model has been evolved which eliminates all contact between the clutch surfaces during rotation. The balls are replaced by rocking elements shown in Fig. 2, which are forced outwards against spring loading by centrifugal forces. The elements engage as soon as the speed drops to about 300 r.p.m. and lock on reversal.

Automatic switching in machines using separate high and low-speed drives can be performed electrically when a ball clutch is used in the following way. The low speed drive is connected to the outer race of a ball clutch through a flexible coupling similar to the freewheel unit shown in Fig. 4. The high speed motor is rigidly connected to both the inner race of the ball clutch and the load. Switching from "off" through "low speed" to "high speed" is accomplished electrically by energising the appropriate motor. The arrangement may be used to reduce the excessive starting current of large high speed motors: a special starting motor provides the initial torque.

Products of Stieber Rollkupplung are marketed in the United Kingdom by Machine Shop Equipment Ltd., Spenser Street, London, SW1.

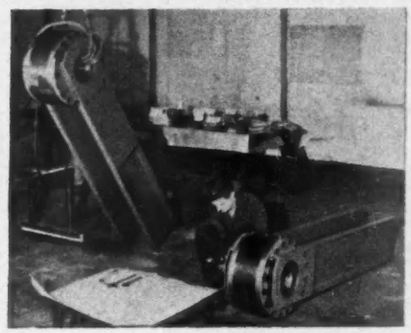


Fig. 3 Two ball clutch units of special construction for a maximum static loading of 180,000 ft-lb. The torque is transmitted by means of the large levers mounted on each side.

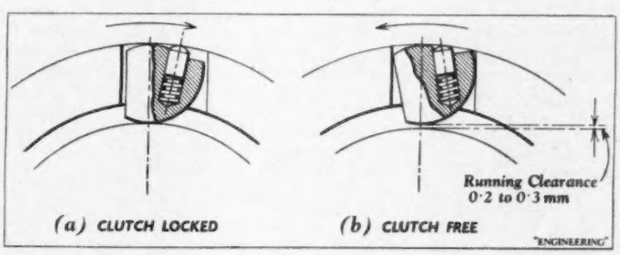
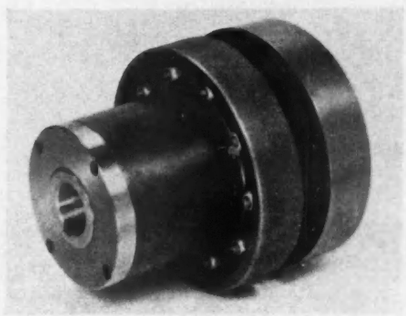


Fig. 2 (left) Design for high speed application elimin ates all contact between the two races.

Fig. 4 (right) Freewheel unit incorporating a flexible coupling, for automatic switching operations.



Rotary Torque Actuator is Positive and Versatile

A new improved rotary torque actuator has been designed to provide 0 to 370° of high torque rotation. Air, gas, water or oil may be used for power. The actuator can be stopped at any point in the rotation cycle, and dead tight seals ensure that it will not slip back under load, shock, vibration, or complete power failure.

The principle of operation is that of a piston free to slide along a shaft, guided so that it cannot rotate and engaging with a helix cut in the shaft.

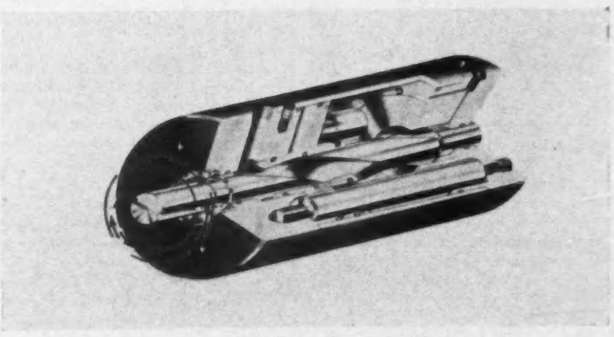
Full cushioning provides smooth, controlled deceleration at the end of either the clockwise or anticlockwise rotation cycle. Thus with 5° of overtravel at the end of either cycle the designer is enabled to utilise full quadrants of rotation in all four standard cycles, namely, 0 to 100°, 0 to 190°, 0 to 280°, and 0 to 370°, overtravel included. Standard bore sizes range between $1\frac{1}{8}$ in and 12 in, and the length, which depends upon the degree of rotation required, varies from about 3 in to a maximum of $21\frac{3}{4}$ in with the 12 in bore × 370° size.

The actuator, developed by Carter Controls Incorporated, of Illinois, USA, is now available in Great Britain through British Arca Regulators, Limited, Gloucester. Possible applications are varied and include indexing cam actions, valve operations, swing motions, progressive turning, agitation, transfer mechanism, dumping, clamping, gate opening, rolling, lifting, maintaining constant tension, and as a device for positioning of all kinds.

Torque output ranges from near zero to 15,000 in-lb depending on the input pressure and bore size of the particular unit. The wide range of torque output is made possible both by the internal helix, and the sealing arrangement, which prevents internal leakage past the piston and external pressure loss.

For some applications it may be desirable to operate the actuator independently from any outside power source. For this reason it is also available with built-in valving, and oil pumps, motor and oil make-up reservoir attached, in which form it is known as the hydraulic rotary power pack unit. The pump is a small gear type with a built-in relief valve and is protected by a filter and reservoir unit; capacities range from $\frac{1}{2}$ to 5 gallons per min at a delivery pressure of 300 lb per sq. in. Motor sizes available are $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, $\frac{3}{4}$, 1 or $1\frac{1}{2}$ h.p. at 1,800 r.p.m. The subplate-mounted 4-way pilot valve can be either a single-solenoid spring offset type in a 2-position detent or a 3-position spring centred type.

Standard actuator mounting styles include foot or flange mounting. Special styles can be ordered. All actuator parts are fully interchangeable to facilitate factory servicing.



Cutaway view of standard rotary actuator with flange mounting. The two side shafts guide the piston which is shown at the forward end of its travel.

A New Automatic Speed Equalising Device

Synchronising the speeds of two or more drives or machines is an everyday problem. A new device fitted to an overhead travelling crane is capable of wide application.

By Ing. Jan Lány

IN engineering practice it is frequently found that the speeds of two or more machines or drives should be synchronised, or should be maintained in a constant ratio without any mechanical interconnection.

Though the so-called "electric shaft" is generally used with electrical machines, there are many instances where this connection is inadequate. This is the case, for example, with the long travel motion of an overhead crane having independently driven end carriages, particularly when starting, travelling or braking with unequal loading on the two ends, or when there are patches of moisture, oil or ice on a rail.

In such applications it is usual to employ selsyns, the purpose of which is to transfer a mechanical displacement to some distant point electrically. Constructionally they are somewhat similar to wound-rotor induction motors, and are used in a transmitter-receiver combination. Previously, applications such as the crane under review have consisted of selsyns using a differential scheme of connection, but these tend to become complex and do not ensure perfect synchronisation of speed and phase angle. The new scheme has been designed to avoid or reduce these difficulties considerably.

Essentially the speeds of travel of the two end carriages are picked up by means of receiving discs of exactly equal diameter and passed via the selsyn transmitters and receivers to a two-part rotary switch, so that a small relative rotation between its two parts caused by the advance of one side of the crane produces a synchronising signal.

The principle of the scheme depends on the fact that any movement can be transformed into a rotary one, this being provided by the slip-free rotating discs which are pressed lightly on to the crane rails. The selsyn transmitters are connected directly to the discs and consequently run in synchronism. The receivers are arranged so that they are coaxial with the two-part rotary switch mounted between them, each part of the switch being mounted on one of the receiver shafts, the two parts being in permanent slight physical contact.

Fig. 1 shows one end-carriage of the travelling crane, each of which carries a selsyn transmitter (1) mounted on a swinging arm (2). On the shaft of each selsyn is mounted a receiving disc (3), which rotates on the crane rails and is held in contact by means of an adjustable spring (4). For correct operation the diameter of the receiving discs (3) must be exactly equal, and their rotation is transmitted electrically to the selsyn receivers which can be mounted at any convenient point on the crane chassis. Figs. 2 and 3 illustrate the receivers (5a) and (5b) and two-way rotary switch. On the shaft of one of the receivers (5a) is mounted a non-conducting hub (6), with an auxiliary disc (7) and a contact disc (8). The other receiver (5b) carries a non-conducting hub (9) with a segment disc (10). A double contact (11) is in constant light engagement with the auxiliary disc (7) and the segment disc (10) which has segments (12), (13) and (14) fixed to it. The contact (11) is fixed to and insulated from the contact disc (8), which is driven by means of friction packing pieces (15) held together by an adjusting nut (16). The contact disc (8) has a beat opening in order that the contacts (11) should be well sprung.

The segment (12) is non-conducting while segments (13) and (14) are conductors, and all three are insulated from segment disc (10) to which they are attached. The hub (6) carries an insulated slip ring (17) which is connected to the auxiliary disc (7), and the hub (9) carries two insulated slip rings (18) and (19), one of which is connected to the conducting segment (13) and the other to the conducting segment (14). Slip ring (17) is connected via a brush (20) to one phase of the supply, while slip rings (18) and (19) are connected via brushes (21) and (22) to the coils of two relays. These are shown as (23) and (24) on Fig. 4, and are arranged to energise solenoids (25) and (26) respectively. Referring back to Fig. 1, these solenoids each disengage the clutch (27) of the driving motor (28) on the advancing end carriage, by means of the tie rod (29) and disengaging lever (30).

During synchronised motion the discs (7), (8 and (10) rotate at the same speed, and since they are relatively at rest the double contact (11) remains in contact with the non-conducting segment (12). However, as soon as there is a difference in speed between the two end carriages, and hence between the segment disc (10) and the contact disc (8), the contact (11) runs on to either conducting segment (13) or (14). Consequently the associated relay (23) or (24) is operated, and solenoid (25) or (26) disengages the corresponding clutch. Reduction in speed of the advancing end of the crane causes the immediate return of contact (11) to the non-conducting segment (12), so that relay (23) or (24) is de-energised and the corresponding clutch recoupled to the motor (28) by the action of its own spring. Thus synchronised running is re-established.

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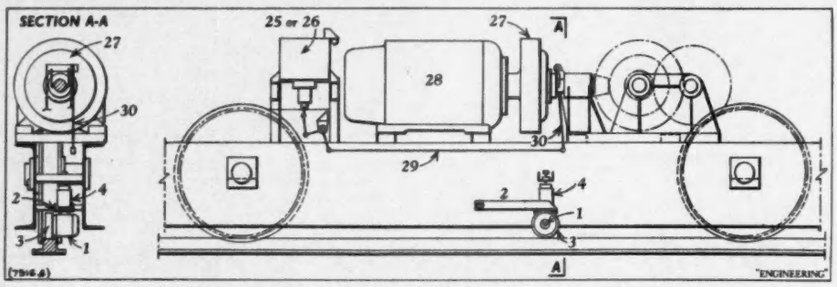


Fig. 1 (Above) Arrangement of equipment on the end-carriage of an overhead travelling crane.

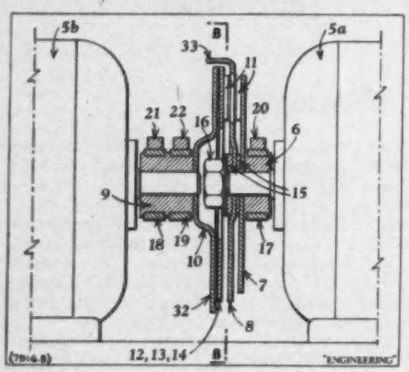


Fig. 2 (Left) Arrangement of two-way rotary switch between the selsyn receivers.

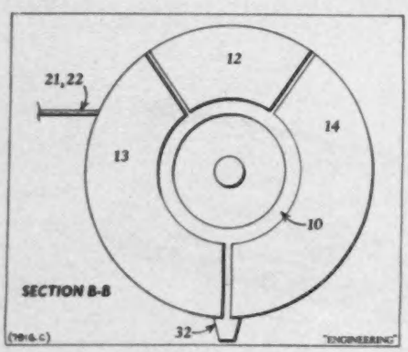


Fig. 3 (Left) Arrangement of conducting (13 and 14) and non-conducting (12) segments in two-way rotary switch.

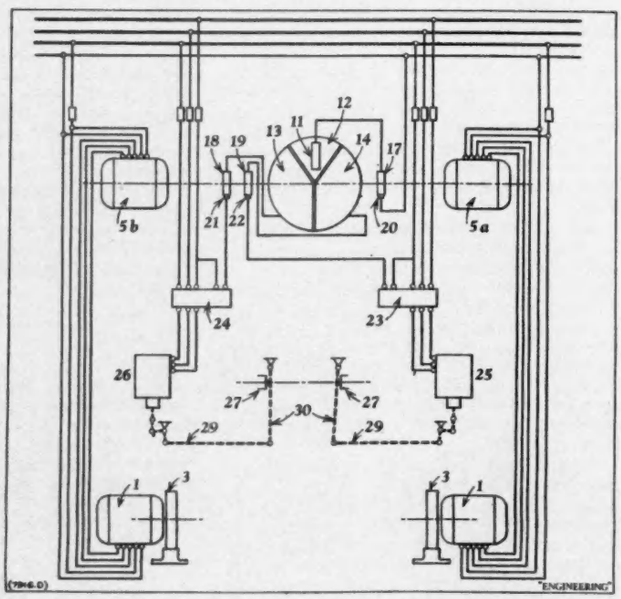


Fig. 4 (Right) Diagram of electrical connections.

Electromagnetic Couplings Have Wide Speed Range

The squirrel-cage induction motor is almost invariably selected for constant speed drive applications due to its inherent simplicity and robustness. It is also used to power the majority of variable speed drives, in conjunction with apparatus providing adjustable output speed from constant speed; this varies from simple pulley changes to complex combinations of d.c. machines and controls, that form large adjustable-voltage systems.

The electromagnetic, or eddy current, coupling is one of the simpler methods of obtaining adjustable output speed from the constant input speed of a squirrel-cage motor; it may be likened to a mechanical slipping clutch. Its use has increased rapidly in recent years because modern designs provide reliability, space economy, high efficiency, and a variety of special operating functions. One of its chief advantages over a mechanical clutch is that it has no physical contact between members to cause wear and require adjustment or replacement, since torque is transmitted by an electromagnetic reaction between the two rotating members. Also the slip produced by this reaction can be continuously controlled much more precisely and over a wider range than is possible with a mechanical clutch.

An electromagnetic coupling has three basic components: a rotor made up of multiple pole pieces, a hollow iron cylinder or drum that surrounds the rotor, and a coil mounted on the rotor and energised with direct current, to provide the system with primary electromagnetic fields. The radial air gaps between the rotor pole pieces and the drum are small relative to the direct gaps between the poles, thus all the magnetic flux flowing between the rotor poles at either end of the coil passes through the drum.

The most advanced designs use variations of these basic principles to improve operating characteristics and mechanical features. Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania, USA, produce Magnaflow drives from 1 to 125 h.p. using the arrangement shown in Fig. 1. The rotor has a large number of " interdigited " poles of special shape to give the most desirable torque characteristics. To avoid the use of slip rings and thus increase reliability, the field coil is stationary, being mounted on the end bracket of the coupling instead of on the rotor, projecting into an annular pocket in the rotor. The extra air gaps thus created do not affect operation, and the rotor poles to the right of the coil are supported from those on the left through a non-magnetic metal support ring integrally welded between the two sets of poles.

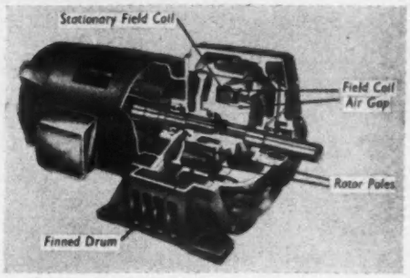


Fig. 1 (Above) Cutaway view of typical stationary-field electromagnetic Magnaflow drive.

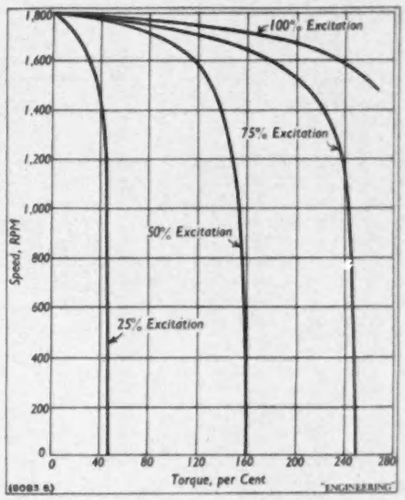


Fig. 2 (Right) Typical speed/torque curves for electromagnetic drives.

The drum in which the eddy currents, and hence heat, are generated acts as the constant speed input member to obtain maximum cooling even when the output member is running at reduced speed. The drum is finned in the case of air cooled couplings as shown, but smooth in the case of liquid cooled couplings. For compactness the motor is flange-mounted on the coupling, and in the smaller drives the motor and coupling are integrated in a single frame.

Westinghouse also produce Magnaflow couplings above 125 h.p., but these represent a further variation from the basic principle, the stationary coil being mounted outside the drum.

The torque produced by an electromagnetic coupling is proportional to primary field excitation and, within limits to slip. Fig. 2 illustrates this by means of four typical speed/torque curves. The changes in torque resulting from varying the excitation provide the means for operating the output at selected speeds below the input speed, the coupling excitation being adjusted so that the coupling and load torques are equal at any desired operating speed. Tachometer feedback control is considered standard for Magnaflow drives, a.c. brushless tachometer generators being incorporated as an integral feature. This control provides a range of speeds that can be preselected by the operator then automatically maintained with variations in load demand, or automatically adjusts the speed through a cycle in coordination with some other process variable.

The losses in an electromagnetic coupling are very small, that due to slip being the most significant. At maximum speed an efficiency of 92 to 96 per cent is the rule, falling to 70 to 75 per cent at about three-quarters of full speed. Therefore the electromagnetic coupling shows up to best advantage for applications where most running is at the high end of the speed range.

This device is a very attractive means of providing adjustable speed, since it requires a minimum of maintenance and has a wide speed range. For example, the Westinghouse Magnaflow drive can provide regulated speed down to 100 r.p.m., and with the popular four-pole induction motor a 17 to 1 regulated speed range can be obtained. Special functions are readily added to the control, either during initial manufacture or in subsequent site modifications. Furthermore, the electromagnetic drive is easily coordinated with other drives of the same or different types.

Concluding New Automatic Speed Equalising Device

To prevent possible damage to the crane if the system fails, a lug (32) shown on Fig. 2 protrudes from the periphery of the segment disc (10), arranged to strike on a curved stop (33) projecting from the edge of the contact disc (8). The lug (32) projects in the lengthened axis of the non-conducting segment (12) and between the two non-conducting segments (13) and (14), while the stop (33) projects in the lengthened axis of the double contact (11). In this way the contact is prevented from running over the gap between the two conducting segments, and making contact with the wrong one due to the packing pieces (31) permitting rotation of the disc (8).

It is claimed that the equalising operation lasts for a period of the order of one-tenth of a second, so that the shock at the moment of re-engagement of the clutch will be quite small, and less than that caused when changing the speed to a higher step on the controller. When stopping the crane, having disengaged the motors, the rotary switch can be used for connecting the brake in such a way that the brake on the more loaded side, i.e. that with the greatest inertia, comes into action first, thus preserving the correct relative position of the two end carriages.

It is considered advisable to admit a small advance of one side of the crane to avoid too frequent operation of the device, the degree of advance being a function of the angle of the non-conducting segment (12).

To ensure the correct functioning of this device under all conditions, the following requirements must be met:—

(*a*) the diameters of the receiving discs must be made and must remain exactly the same.

(*b*) There must be no slip between the receiving discs and the rails.

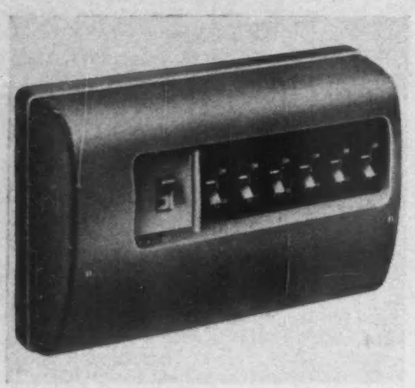
To satisfy (*a*) it is recommended that both the discs should be cut from the same bar of a wear-resisting material, e.g. case hardened steel. The torque requirements of the selsyn transmitters should also be kept to a minimum.

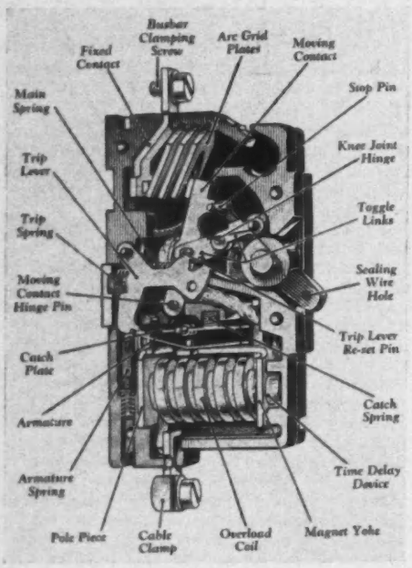
With regard to (*b*), it is recommended that the disc material should have as high a frictional value as possible, and also the pressure of the receiving disc against the rails should be so adjusted that the pressure is a minimum consistent with no slipping.

One of the main advantages of this device is that it is entirely independent of the method of propulsion, and it is thus capable of very wide and varied application. It is suitable, for example, for hoisting devices, conveyor belt systems, ships or aircraft, all with two or more separate drives. Since in all cases the power transmitted between the selsyns is very small, only light wiring will be required, together with the advantage that there is no practical limitation on the distance between the machines to be run synchronised.

One disadvantage of using this device could occur if used in conjunction with a drive motored by slipring induction machines with plain rotor resistance control. In this case if a motor were suddenly declutched from its load while accelerating, its speed would tend to rise to near the synchronous speed. Consequently it would be expected that the jolt when the clutch re-engages may be more appreciable than claimed, and in fact may cause the declutched side of the crane to advance too far and therefore be declutched again. This hunting phenomenon could become continuous if the angle of the non-conducting segment (12) is too small, and may possibly occur not only when accelerating but also when running at full speed.

Miniature Circuit-Breakers for Domestic Use





Miniature circuit-breakers that seriously challenge the use of rewirable fuses, in domestic and industrial installations, are now being produced. Although more expensive than the fuse units they replace, they are easier to use. In situations where a high standard of accommodation is required they are finding increasing application.

J. A. Crabtree and Company Limited are making an all-insulated consumer's unit embodying circuit-breaker protection. As will be seen in Fig. 1, a main switch is incorporated in the unit together with up to six type C-50 circuit-breakers. The main isolating switch is a double-pole unit rated at 60A, while the circuit-breakers can be designed to trip at various ratings from 2·5 to 50A.

The type C-50 circuit-breaker has an electromagnetically operated tripping mechanism: all ratings are set to trip on a sustained 30 per cent overload. Positive control both in the "on" and "off" position is provided by the operating lever, which controls the main contact through a collapsible over-centre toggle mechanism. The breaker can always be manually operated.

The overload coil triggering the tripping mechanism is situated at the bottom of the unit (Fig. 2). Loading of the armature provides an inverse time-current delay device, so that harmless transient overloads do not cause "nuisance" tripping; but instantaneous triggering occurs with heavy overloads or short-circuit conditions. All ratings are set to trip on a sustained 30 per cent overload.

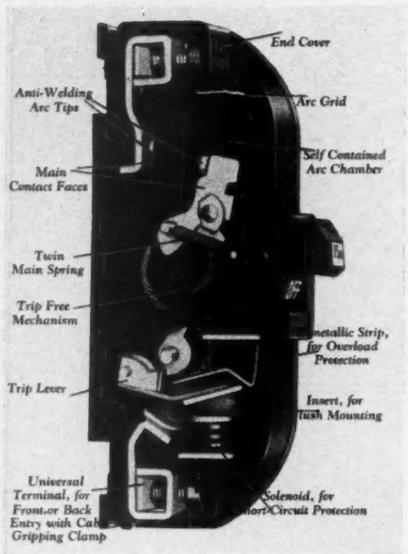
A small circuit-breaker suitable for use in domestic consumer units is also made by the MCB Company (Manchester) Limited. The Lupus Midget, as it is called, uses a bimetallic trip in conjunction with an electromagnetic tripping system, to provide the required time-delay characteristic (Fig. 3). A relatively long time delay before tripping is provided for small currents by the bimetal action. A very short time delay for serious overloads results from electromagnetically-assisted bimetal action. Instantaneous tripping on short circuit conditions is produced by electromagnetic action, which predominates at 12 times the rated current.

The Midget is available for up to 440V a.c. and 125V d.c., with standard current ratings of 5, 10, 15, 20, 30, 50 and 60A. It is a development of a previous model, the Senior. The spring and magnetic circuit of the overload device have been made more efficient, and a fine adjusting screw allows more accurate calibration. The arc chamber has a ribbed opening closed by a metal grid, which allows ventilation and the escape of gases, while controlling the arc in case of short circuit.

Fig. 1 (top left) An all-insulated consumer's unit in which circuit-breakers replace fuses.

Fig. 2 (lower left) Interior view of the type C-50 miniature circuit-breaker, showing the overload coil, time-delay, and tripping mechanism.

Fig. 3 (right) Interior view of the Lupus Midget circuit-breaker, showing combined bimetallic and electro-magnetic tripping mechanism.



Slipping Clutch for Overload Control

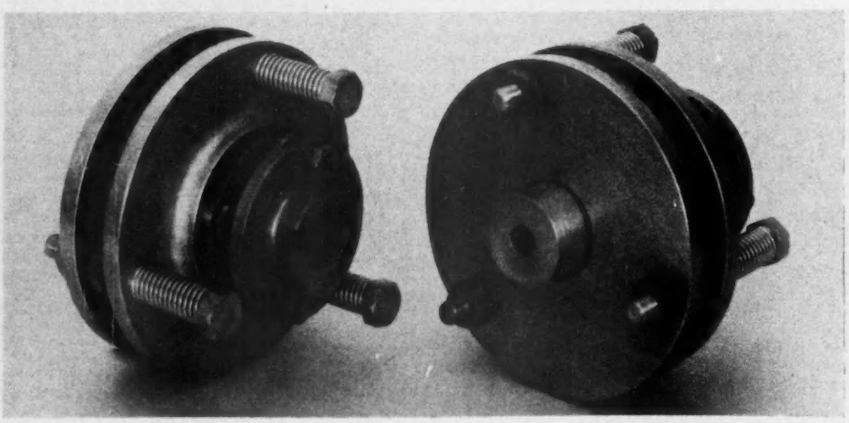
A small slipping clutch, which may be preset to transmit a given maximum torque, has been developed by Metaducts Limited to serve as an overload controller. It has been designed as a safety feature, particularly for use on motor-driven rotary transformers providing unattended automatic voltage regulation.

On these installations a limit switch should cut out the operating geared motor at each end of its possible travel. In the event of limit-switch failure, where a slipping clutch has been fitted, the motor can continue to run against some desirable preset maximum torque instead of running stalled and possibly burning out.

The clutch was developed for Foster Transformers Limited and following successful operation in service it is now to be manufactured as the first of a projected general range. It will be suitable for use in drives where control is effected by fixed stops or where there is a danger of stalling. In comparison with devices employing shear pins, the slipping clutch permits greater control of the maximum torque, and in many applications may be preferred to centrifugal clutches, which become prohibitively large and expensive where drive speeds are low.

The clutch is made of close-grain cast iron, cadmium plated, except for the area covered by the friction discs. A Metastream CN flexible coupling, in either single or double bank form, is incorporated, to accommodate angular and shaft-ends distance misalignment without sensibly affecting the pressure on the friction plates. A small clearance between the input hub and enclosure plate allows a small measure of parallel misalignment. The slipping torque is controlled by adjustment of three bolts holding the plates in contact by spring pressure. In the present version the slipping torque is adjustable up to approximately 5 lb-ft, irrespective of speed. The clutch is made by Metaducts Limited, Catherine Wheel Road, Brentford, Middlesex.

The Metastream slipping clutch may be preset to transmit a given maximum torque and is suitable even for low-speed drives.



Bearing Wear in Corrosive Atmospheres

The provision of high temperature bearings for use within carbon dioxide cooled nuclear reactors presents many problems. Research carried out by the English Electric Company has gone a long way towards finding a solution.

By H. H. Heath, A.M.I.Mech.E.

Atomic Power Division, English Electric Company Limited

THE Engineering Laboratories of English Electric's Atomic Power Division have the task of providing an engineering service, both by carrying out programmes of research and development and by assisting other laboratories in the design and acquisition of specialised experimental equipment. To do this effectively the Laboratories are divided into three sections: mechanical, full-scale test, and rig design.

Mechanical Laboratory.—This laboratory is responsible for research into basic mechanical problems and for the development of plant items.

Considerable attention is given to evaluating the products of the open market which could be of use. This has been specially true of work done in selecting and proving gas valves, and in finding low-leakage gland packings and gasket materials. It has also been necessary to investigate the long-term behaviour of rubber when used as a gas seal in the form of an "O" ring.

An interesting example of a device which has been developed by this laboratory is a shock absorber which provides a simple and reliable means of preventing falling objects from damaging parts of a reactor. The shock absorber consists of a steel tube which, if properly held and preformed, collapses into a series of regular convolutions when struck axially. Fig. 1 shows such a device. The tube shown is 1½ in diameter and 23 s.w.g. thick. During collapse a mean resisting load of 2,800 lb was found.

A number of plant items for the Hinkley Point reactors have undergone exhaustive proving in the Laboratory. Examples of this type of work are: control-rod actuating mechanisms, grabs for the insertion and removal of fuel, and fatigue properties of the wire cables which are used to support control rods, to mention only a few.

Full-scale Test Laboratory.—This Laboratory takes complete systems and large items of reactor equipment and does the development and proving work required.

A major commitment at present is to prove the fuelling machinery for the Hinkley Point reactors before they are delivered to site. A full-scale assembly which simulates a part of the reactor core has been built and installed in a pit 85 ft in depth. It is possible to establish in this the gas flow, temperature and pressure conditions which will be found in the reactor. Using the assembly a full operational check of the machinery's functions will be made.

Measurements are also to be done on such things as temperature levels within the machine, and of the flow patterns of cooling gas, to serve as a guide for future designs.

Much of the machinery handled is closely interlocked and carries quite complicated control gear. The opportunity is taken during full-scale tests to check that the controls, instruments and operation all come together as a well-behaved, integrated system.

Rig Design Section.—The third aspect of the Engineering Laboratories' activities is the provision of a design service, not only to the Mechanical and Full-scale Test Laboratories, but for others in the development department who are concerned with heat transfer, fuel element and metallurgical research.

AROMATIC GREASES

One of the most interesting tasks carried out at the Engineering Laboratories of the English Electric Company's Atomic Power Division is that of providing suitable bearings and lubricants for use within the pressure vessels of carbon dioxide cooled reactors. In these reactors there are atmospheres of CO_2 at pressures about 200 lb per sq. in and at temperatures ranging from 20° to 400° C. In some places there will be intense fluxes of nuclear radiation. The materials chosen must be thermally and chemically stable in CO_2 up to the working temperature, and in addition either they must be such that they do not react with, nor form low-melting-point alloys with the fuel elements, or they must be contained so that they are kept rigorously from even accidental contact with the fuel elements.

For applications where the temperature is lower than 150° C it is possible to use grease.

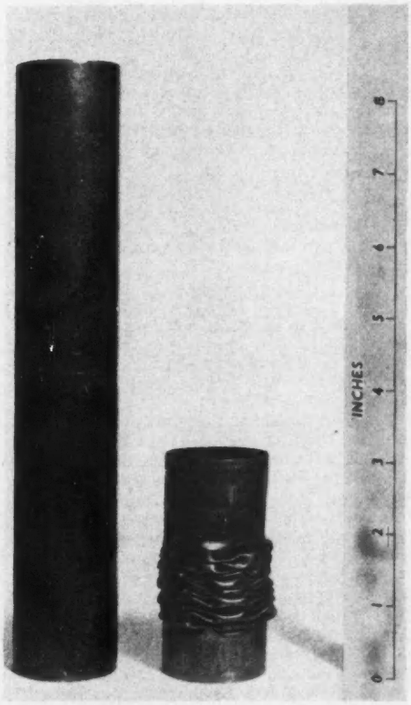


Fig. 1 (above) Collapsing tube shock absorber before and after it has absorbed 1,300 ft-lb of energy.

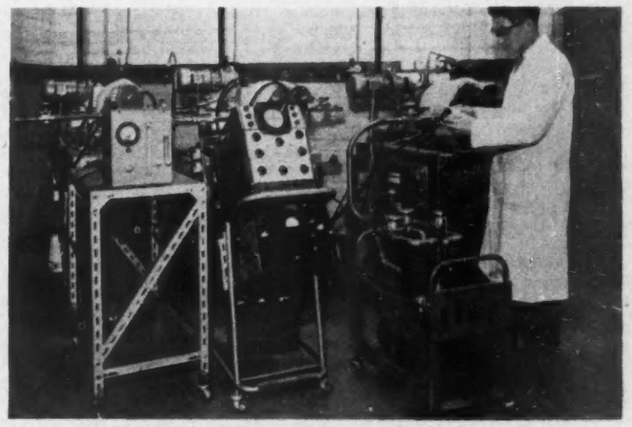


Fig. 2 (right) A number of reciprocating wear machines are used in the friction laboratory.

For vital mechanisms such as control-rod actuators the use of grease allows the designer to use well-established engineering practice, with a consequent gain in reliability.

The greases used must be properly compounded. The difficulty does not usually lie, as might be thought, in providing resistance to nuclear radiation; hydrocarbon products as a class have excellent resistance to radiation. Furthermore, it has been found that aromatic hydrocarbons are more than usually resistant, and by selecting the oils used in the grease manufacture to be rich in aromatics it is possible to improve the radiation life by an order of one magnitude or more. A normal grease might successfully withstand a total integrated radiation dose of 10^8 rads and a selected product more than 10^9 rads. Such irradiation life is usually required only in situations when the operating temperatures are too high for grease to be used anyway.

Chemical stability proves to be a greater hazard for the unwary than radiation resistance. It might be thought that any grease with good oxidation resistance in air would have more than adequate stability in CO_2. However, early work showed that many of the standard grease products based on metallic soaps reacted with CO_2 and became useless after a few hours running at high temperature. Fortunately, it is possible to prepare non-metallic greases with both enhanced radiation life and ability to run for thousands of hours in CO_2 at 150° C.

Tests were done on ball bearings, on gears and on complete mechanisms and it was shown that satisfactory lubrication was possible with these products and that careful attention to seal design could ensure that the grease charge could be contained over a wide range of temperatures and gas pressure cycles.

When the temperature is nearer 400° C, a completely different approach to grease is needed. It was recognised at the outset that considerable research and development work would be needed before this problem could be even partially solved, and a section of the Mechanical Laboratory was set aside for this purpose. A pin and disc machine was built on which to do sorting tests. A number of reciprocating machines was also designed and built, these were constructed to use small and simply-made specimens in conditions of reciprocating wear, under closely controlled atmospheric conditions and with a continuous measure of the frictional forces. Before a run was done in the reciprocating machines the specimens

Continued on next page

were degassed under vacuum and then a known atmosphere was admitted to the test chamber. In addition a number of rigs was built with the object of checking the performance of typical engineering components such as gears and ball bearings. Fig. 2 shows some of the reciprocating rigs in this laboratory.

GRAPHITE

The use of graphite as a bearing material either in the massive form or as a thin colloidal film on a metallic base was considered at an early stage. It was known that graphite could suffer catastrophic wear when run in air of low humidity, this phenomenon was found during the last war in the carbon brushes of high-flying aircraft generators. However, it was not clear whether a similar effect would be found in the dry CO_2 atmospheres (about 100 parts per million of water vapour) which are found in reactors.

After preliminary sorting tests a commercially available electrographite, EY9106 (made by the Morgan Crucible Company), was selected as a promising material. Although when run against itself at 400° C wear was unacceptably high, no wear at all was found when run against En41 nitrided steel for 1,000 ft in a reciprocating machine with an applied load of 13·6 lb (146 lb per sq. in). The coefficient of friction for both the graphite-on-graphite and the graphite-on-

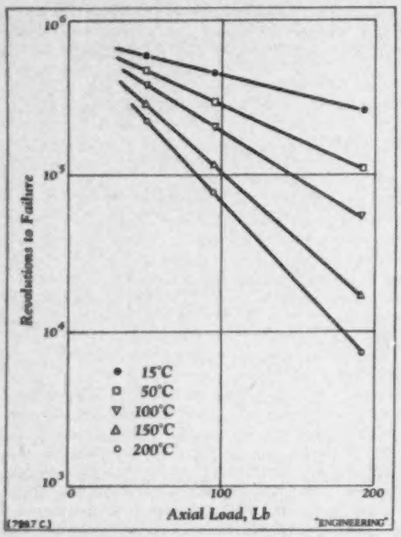


Fig. 3 Effect of load on revolutions to failure for a standard angular contact ball bearing.

steel combinations was very variable, ranging between 0·4 and 0·05. Variation was found both between runs and during runs, and appears to be due not so much to changed experimental conditions as to more or less random variations in the surface condition of the graphite. Graphite against stainless En58B had a similar variable coefficient of friction, but wear was very great.

A series of experiments was then run to see what effect, if any, the presence of dry CO_2 had on the lubricating properties of the graphite. A graphite-on-graphite combination was set up in one of the reciprocating machines and after degassing under vacuum was run alternately in a high vacuum and in dry CO_2. Friction was higher in high vacuum than in dry CO_2 and the total wear was higher than would have been expected from a run of the same length of time in CO_2 alone. A similar effect was found when dry nitrogen was alternated with dry CO_2. In a third experiment dry air was alternated with CO_2, and here we found that friction was less in air, although the total wear was again greater than for CO_2 alone. This apparent anomaly is an indication of the fact that there is no guarantee that low friction implies low wear. It seems certain from these results that dry CO_2, at least on the type of graphite tested, has the ability to reduce the wear of graphite. The encouraging results with the graphite-on-nitrided-steel combination have been subsequently confirmed in a number of practical applications.

In some applications the low coefficient of expansion and the low strength of massive graphite make it undesirable. A series of experiments with colloidal graphite laid on a mild steel base was therefore carried out.

One of the principle difficulties of obtaining a long-lasting graphite film is to ensure that it is well bonded to the metal substrate. The adhesive resins which are often used to bond a graphite film to metal are not stable to temperatures of 400° C, and preliminary experiments proved that there was no advantage in using such products as compared with films deposited directly from colloidal graphite in water.

On the reciprocating machines with loads of 13·6 lb (146 lb per sq. in) the life of the films was limited to a few thousand feet of continuous running. If running was not continuous life was often very much shorter. This effect was traced to the fact that, when a graphite film has been run, one or two temperature cycles from room temperature to 400° C are sufficient to disrupt the adhesive forces and cause the film to lift.

A large number of additives was mixed with the graphite in the film in an attempt to improve the life. Among those tested were PbO, Pb_3O_4, $PbCO_3$, $PbMoO_4$, PbS, $PbSO_4$, CdO, $Cd(OH)_2$, $CdCO_3$, Na_2CO_3 and silica aerogels. In no case was there a significant all-round improvement in performance. It was usually found that the additives with the greatest beneficial effect were the most likely to undergo chemical change in CO_2 at 400° C.

It was concluded from this work that reliance could not be placed on graphite films as lubricants for our reactor conditions and attention was turned to the investigation of completely unlubricated metals.

UNLUBRICATED METALS

The main metals tested are given in the Table. It was not possible in the time available to run each of these materials against itself and all the others, nevertheless enough work was done to establish the general pattern of performance.

It became apparent that the harder materials, provided they did not have pretensions to being stainless, gave the best performance.

The three best materials were the two nitriding steels and the tool steel. These gave good results when run against themselves, against each other, and against most of the other materials tested.

Typical wear rates when these metals were run as bearing pairs were 1 microgram weight loss per foot of run when tested in a reciprocating machine with a 13·6 lb load (146 lb per sq. in).

There is not much to choose between these materials as bearing surfaces but the simpler heat treatment and easier machining properties of nitriding steels means that they are often to be preferred. A word of caution is necessary on the use of nitrided steels, however. It is not always recognised that on the surface of the nitrided skin there is a hard brittle layer of material rich in Fe_2N. This layer, which is often known as the " white layer " from its appearance on metallographically etched specimens, is about 0·0015 in in thickness and should be removed before bearings are run.

Table of Metals Tested as Bearing Surfaces

Metal	*Hardness (VPN)*
Nitriding steel En41A	1,000
Nitriding steel En40B	900
High-speed tool steel	850
Die steel	675
Martensitic stainless steel En56D	540
Martensitic stainless steel En57	460
Acicular iron	455
Hard chrome plate	450
Spheroidal graphite cast iron BS2789—type 1	300
Mild steel En3A	220
Titanium	215
Low-chrome steel En31	210
Spheroidal graphite ductile Niresist	200
Austenitic stainles steel En58B	185
Type 1—Niresist	165

The break-up of the white layer under load was found to be very marked when nitrided gears were run together without lubrication. Once the white layer had been removed by lapping, the gears were completely satisfactory.

The coefficient of friction of the unlubricated metals, like graphite, varied widely, ranging from about 0·3 to 0·8. Such high friction is rarely a disadvantage in reactor mechanisms from the point of view of power limitation but the high values of friction involved place severe restraints on the design of link mechanisms.

It was found that generally both wear and friction were lower at 400° C than at room temperature. This is attributed to the protective effects of metal oxides, which are more freely formed at the higher temperatures. The practical results of this are important. It is possible that a machine which will operate satisfactorily at full temperature will fail to do so when run cold on test because the friction level has risen. It is also false to argue that it is a good thing to increase the temperature during proving runs above those expected in service as a " safety factor." It may well be that the wear conditions at the increased temperature are made easier rather than more severe. No effect of CO_2 humidity on friction and wear has been found over the range 50 to 1,000 parts per million of water.

One of the most noticeable features of work

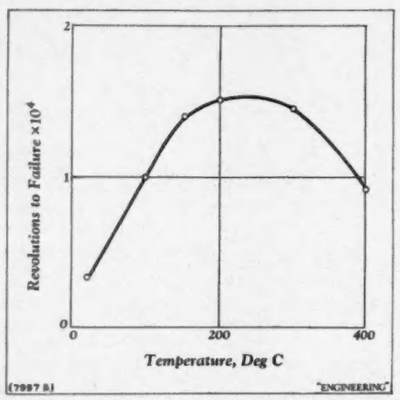


Fig. 4 Effect of temperature on revolutions to failure for high temperature angular contact ball bearings.

with unlubricated metals is the very large amount of oxidised wear debris which is produced. This happens even when the wear rate is low. The appearance of an unlubricated metal bearing after a period of running is strongly reminiscent of fretting, and there can be little doubt that the mechanisms involved in fretting are very similar to those in metallic wear. It is interesting to note that as oxidation of wear particles can occur in the presence of trace amounts of oxygen, attempts to suppress it by running in nitrogen say, are of no avail. Runs in vacuum however cause very severe wear, no doubt due to lack of oxygen.

It seems likely that it is the form of the oxide film which in some way makes stainless materials rather poor in wear resistance. One can imagine that the hard oxide film which forms on the surface of stainless steel is also brittle and under the heavy stresses induced during the wear process it breaks up to expose areas of unprotected metal. The less corrosion resistant materials have a more loosely attached oxide layer which can yield under the load without being completely penetrated.

The protective value of the oxide layer is still, however, far from being understood. For example, some attempts to use massive metallic oxides in the form of ceramic compounds have met with no success. In fact ceramics generally have been found to have very poor wear properties, in spite of their great hardness.

A consequence of the large amount of debris which is found is that very careful consideration

Bluebird to Yield Data on Lubrication

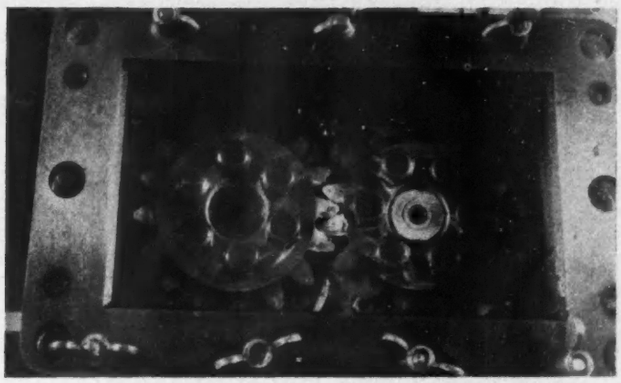
The new Bluebird car being built for Donald Campbell's attempt on the world's land speed record next September has been described as a laboratory on wheels. Not only has the research and testing of the component parts yielded valuable information which should ultimately benefit the ordinary motorist, but a great deal of data will be yielded on the trial runs and the final record attempt. Much of this data will be useful to the research staff of the British Petroleum Company, which is providing all the fuel and lubricants for the record attempt.

No less than eighteen measuring gauges will be fitted to various parts of Bluebird, revealing such information as corrections to wheel steering, power turbine r.p.m., and vertical acceleration, which is a measure of any lifting movement caused by bumps on the course. Every reading will be electronically transmitted by a telemetry system from the car to a central instrument board which will be set up on the Salt Lake Flats. Nine of these gauges will reveal information on the performance of the lubricants: four will show gearbox bearing temperatures, two will give gearbox oil outlet temperatures, two others will indicate gearbox oil manifold pressures and one will measure the engine oil pressure.

The fuel to be used is regular BP aviation turbine kerosine and, in addition, seven different lubricants and greases will be supplied. The lubricants will be for transmission gearboxes, engine, steering, suspension, wheels, brakes and general greasing. Most of the oil has been blended at BP's Llandarcy refinery in South Wales and filled directly into specially labelled containers for shipment to the Bonneville salt flats.

One of the most difficult tasks faced by the research staff at BP has been to blend a suitable lubricant for the two gearboxes. After an initial study of the problem, it became apparent that the loads on the reduction gears would be far greater than those normally met either in production cars or racing cars. There were two main requirements; the shaft bearings required a free-flowing thin oil in sufficient quantity to circulate rapidly and cool the rolling surfaces, while at the same time it had to have the very high film strength necessary to prevent metal to metal contact. Calculations showed that at a speed of 475 m.p.h. the load on the gear teeth would be 3,350 lb per sq. in. However, the most critical point will be when the car is being revved up on the brakes, just before the run. At this stage the load on the gear teeth will be over 4,000 lb per sq. in.

A number of blends of lubricants were prepared at BP's research centre at Sunbury-on-Thames and tested over a period of eight months on a range of specially built devices, including a gear machine (see illustration), which was used to test gearbox lubricants under operational conditions. This machine was made to run at a speed of 9,000 r.p.m.



A machine has been developed in which two mesh gears can be run at various speeds and torques. Oil is injected between the teeth until rising smoke indicates that the oil film has broken down.

The machine consists of two meshed gears, behind a glass panel, which can be run at various speeds and varying amounts of torque. Oil is injected between the meshed teeth and the test conducted by running the gears at steadily increasing speed until the oil film breaks down. When this happens, the metal to metal contact causes smoke to appear in the test box, indicating surface damage to the teeth. The procedure from then on is try new blends until one is found which will stand up to the required load.

While these tests showed that an oil of the required load performance could be produced, it was further necessary to ensure that the oil would not fail to operate due to high speed and windage effects. This can occur when the centrifugal effect of the revolving gears throws off the oil, or when windage prevents free flow.

A test rig was built in which the bevel gears could be driven at high speed, and the action of the oil studied visually. Early tests showed that the jets of oil ducted on to the teeth were in fact deflected by windage at top speed and the quantity actually reaching the surface was insufficient for lubrication and cooling, there was also a tendency to "foam." This resulted in modifications to the oil distributing pipes and systems and further tests had to be carried out before an adequate flow was assured. The foaming problem was dealt with by the addition of an anti-foaming agent.

Concluding **Bearing Wear in Corrosive Atmospheres**

must be given to its disposal from bearings. The density of the oxidised wear debris is low and occupies much more space than the metal which has been removed, it may thus rapidly fill the bearing clearances. With unlubricated metal journal bearings in particular, seizure due to jamming by debris is a very real problem.

Several practical applications including such things as unlubricated journal bearings and gear trains have been designed and proved using the results obtained from these experiments.

UNLUBRICATED BALL BEARINGS

The wear conditions in rolling element bearings are an interesting mixture of rolling and sliding. In order to obtain an overall picture of the problems of running ball bearings without lubrication a series of experiments was done using completely standard products.

The bearings chosen were medium series angular contact, with a bore of 25 mm and with machined brass cages. They were mounted with the shaft vertical in a test chamber and run for periods of 26,000 revolutions at 1,440 r.p.m. with an axial load and then left at the test temperature for half an hour before the process was repeated. This continued until a distinct change in the noise level indicated incipient bearing failure.

Before each run the test chamber was exhausted to a pressure of below 100 microns of mercury absolute for one hour and was then filled with CO_2 to a pressure of 5 lb per sq. in gauge.

The tempering temperature of the ball-bearing steel used may be taken as about 140° C and, as might well be expected, the life fell rapidly as this temperature was exceeded. When the bearings were examined after failure damage was limited in the main to transfer from the brass cages to the balls and tracks. An interesting relationship was found between bearing life and axial load of the form: Life $\propto e^{-aW}$, where W is the axial load.

Typical results for a range of temperatures are plotted in Fig. 3.

This relationship contrasts with that found for lubricated bearings where it is found that $(\text{Life})^3$ is proportional to Load.

It seems not unreasonable that this difference should be found because under lubricated conditions the cause of bearing failure is fatigue, whereas under these unlubricated conditions, failure took place by metal transfer before fatigue could make itself felt.

The surprising thing about these results is that it is possible to get a life of between 10^4 and 10^5 revolutions with quite respectable loads at 200° C and with no lubrication on a completely standard bearing.

Following this work a number of special bearings, tempered for use up to 400° C and fitted with machined En57 cages, were obtained and tested. Once again a life/load relationship of the form: Life $\propto e^{-aW}$, was found.

Whereas in the case of standard bearings an increase in temperature always had the effect of decreasing the life, the special bearings appeared to have a best life at a temperature somewhere between 200 and 250° C. Fig. 4 illustrates this effect. At low and high temperatures failure was due to metal transfer from the cage to the balls and tracks, as in the case of the standard bearings, but at temperatures near 200° C failure appeared to be due to race breakdown, due in turn to wear.

It is felt that the peak in the life versus temperature curve is associated with a balance between the rate of formation of oxide and the rate of metal transfer.

Work presently in hand indicates that much-improved performance can be obtained either by using hardened cages or by omitting the cage and running with a full complement of balls.

CONCLUSIONS

The problem of providing adequate high-temperature bearings for CO_2-cooled reactors is far from beaten, but some quite firm general points are clear at this stage.

So far there appears to be no reliable method of using colloidal graphite films as a lubricant. It is, however, possible to select a graphite in massive form which shows good wear properties when run against nitrided steel. The coefficient of friction of graphite-on-graphite or of a graphite on-nitrided steel bearing pair is variable, and may be expected to rise as high as 0·4 in in the first case and 0·8 in the second.

Nitrided steels and tool steel can be made to behave well even when run together with no lubrication, provided that proper care is taken to get rid of the wear debris.

It seems, too, that rolling-element bearings can be developed to provide very good service under conditions found in these reactors.

New Horizon—100 kW

THE theme of the recent British Electrical Power Convention was the "New Horizon" and one of the papers, presented by Mr. T. E. Daniel, set the sights for the horizon in the home. It came as quite a shock to many that a home loading of 100 kW would have to be catered for in the not too distant future.

It is not really surprising that such a figure should seem large—only 20 years ago there were not many factories that could show a greater demand. Yet it is not a guess, but a figure made up by simple addition of the various items common to most homes. A table listed some 80 of them—and there were comments that it was not complete. Provision for such a loading will certainly pose a problem to the electricity supply industry involving the laying of more distribution lines (with all the consequent upheaval of traffic) as well as installation of more generating plant. The greatest worry, however, seemed to be the obtaining necessary finance for the work. A summary of the loading and costs (derived from the fully detailed schedule given in the paper) is given in the table, for a three bedroom house.

Summary of Installation Points and Loads

Lighting		
22—1 way, 5—2 way, 12—socket outlet		3·68 kW
Heating		
Floorwarming 9·3 k } off-peak		12·00 kW
Ceiling heating 2·7 k }		
Casual heating, 14 spur boxes 17·06kW connected		17·06 kW
Cooking		15·50 kW
Water Heating		
Main supply, 50 gall. storage—Ind. circuit		4·5 kW
Instantaneous heater—1 spur box		3·0 kW
Waterboiler—1 spur box		3·0 kW
Other outlets required, including appliance load		
30—S/O. 3 clock points. 8 spur boxes		36·04 kW
	Total load	94·78 kW

Total wiring excluding basic heating, cooking and water heating:
22—1 way lighting points
5—2 way lighting points
42—socket outlets
3—clock points
24—spur boxes

Appreciation of consumption

Off-peak	Heating	17,000 kWh	
	Water heating	3,000 kWh	
		20,000 kWh	at NWEB* off-peak tariff (0·8*d*/kWh) = £66 13*s* 0*d* per annum
On-peak	Cooking	2,000 kWh	
	Casual heating	3,500 kWh	
	Lighting	400 kWh	
	Ancillary appliances	4,800 kWh	
		10,700 kWh	at NWEB domestic tariff = £46 16*s* 0*d* p.a.
	Total	£113 9*s* 0*d* p.a.	

* NWEB = North Western Electricity Board

A large part of the increase in loading, but by no means all, would probably be in the field of space heating. Mr. Daniel estimated an annual consumption of 17,000 units for this purpose in a three bedroom house, or about two thirds of their total requirement. Off-peak use of electricity for heating was obviously desirable and therefore some form of heat storage was required. For new homes, the problem was solved by floor installations, but for older houses, the obvious way, using block storage heaters, was not available since manufacturers would not sell them to domestic users. If they did, purchase tax would be imposed on both domestic and industrial sales. Reference was also made to work by the Electrical Research Association on methods of heat storage utilising latent heat of fusion. Financial considerations had prevented this being extended.

When regarded from the safety aspect, electricity offered the best choice of fuel as accident records showed. But the rapidly increasing number of appliances meant that unless more socket outlets were provided most houses would become a dangerous tangle of trailing flexes, with marvellous Christmas trees of plugs emerging from a single socket. Increasing size of appliances suggested that the present plug capacity of 3 kW (based on the standard 13A type) was insufficient and a 25A plug should be produced. Since so many electrical accidents arise from faulty plugs, good design would be needed. The idea was, however, opposed on the grounds that any appliance drawing 3 kW or more should have a permanent connection from a spur box. But, in any case, more thought and planning of the electrical system should be put into the house at the time of building. In the United States, those new houses which comply with certain standards for equipment and wiring are being awarded medallions which are permanently and visibly fixed to the fabric.

The paper drew forth one complaint—that it did not give enough prominence to the improvement of lighting. Modern living demands a much higher intensity of light than ever before, in spite of the darkness needed for the comfortable enjoyment of television. Where once the standard fitting consisted of a single lamp suspended precariously by a flex from the centre of the ceiling, now there are often a spray of lights placed centrally, wall brackets, and standard lamps at strategic points. Indeed, the lighting load for Mr. Daniel's three-bedroomed house amounted to 3·68 kW. The belief that too much light is bad for the eyes dies hard—it takes a lot of 100 watt lamps to be as bright as the sun even on a dull day. Concentration of light with intense shadows might be bad—it is certainly uncomfortable—but the aim now is to get even distribution.

Several publications are available from the Electrical Development Association outlining wiring for the home and showing details of ring circuits and what outlets are needed in the rooms. Another publication by Crabtree entitled "Design for Living" is in the same field and illustrates electrical fittings in the various rooms. Anyone building a house or planning a major alteration should study the literature available to get a guide as to what provision should be made.

Another point made by Mr. Daniel is the reluctance of most folk to spend out on improving, or even on maintaining, the wiring system. A new appliance shows—it is something to use and be proud of, but wiring is out of sight, and (as long as it works) out of mind. It is important to remember that the addition of new appliances imposes additional loads on wiring, which may have been quite adequate for the supply when originally installed but will not pass double the amount without overheating. Moreover, although undisturbed wiring even though very old, is perfectly safe, yet alterations and additions may quickly cause breakdown. It was suggested that some regular servicing agreement might be worked out by the local electricity boards for the upkeep of both wiring and appliances.

In summing up the factors influencing the trends to the all-electric house, Mr. Daniel throws a challenge to the electrical industry. "The imminence of many smoke control areas in our built-up areas should make thousands of wage earning domestic consumers face up to the question of whether they should turn over entirely to electricity. Why are there few signs of any changeover to electricity in these areas? Firstly, the subsidy terms favour the cheapest initial cost of conversion. Secondly, we have no thermal storage heating systems to offer for existing houses and the public is still begrudging a reasonable expenditure on fuel. Thirdly, the public prefer staggered and "pay-as-you-go" fuel bills to heavy quarterly ones. Fourthly, we have not promoted improved wiring vigorously enough or popularised easy payment terms for it. Fifthly, we have no ready solution to the waste disposal problem. Sixthly, voltage and supply security and restoration are not always beyond reproach and appliance repairs become a matter of greater urgency if a single fuel is to be relied upon."

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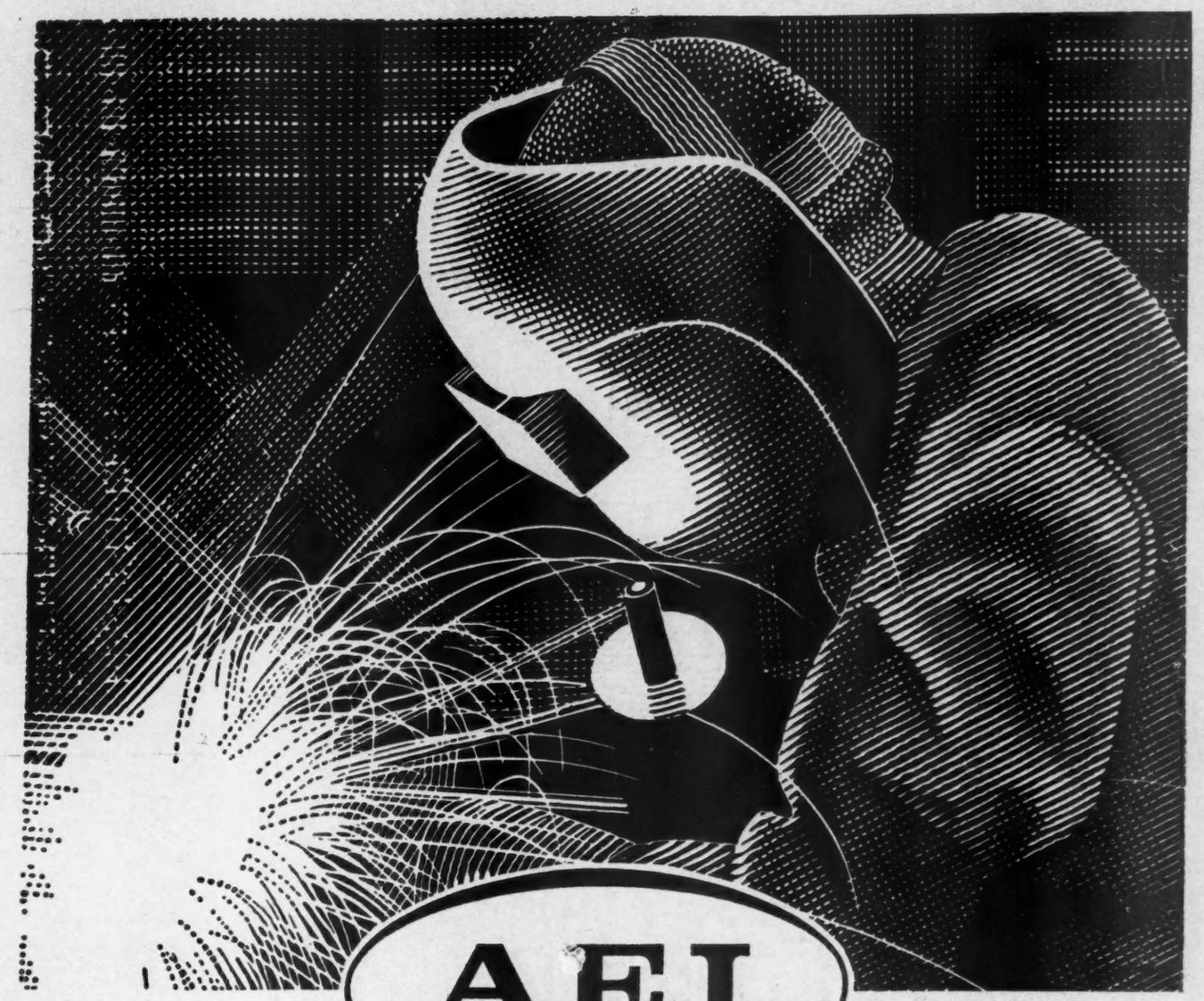

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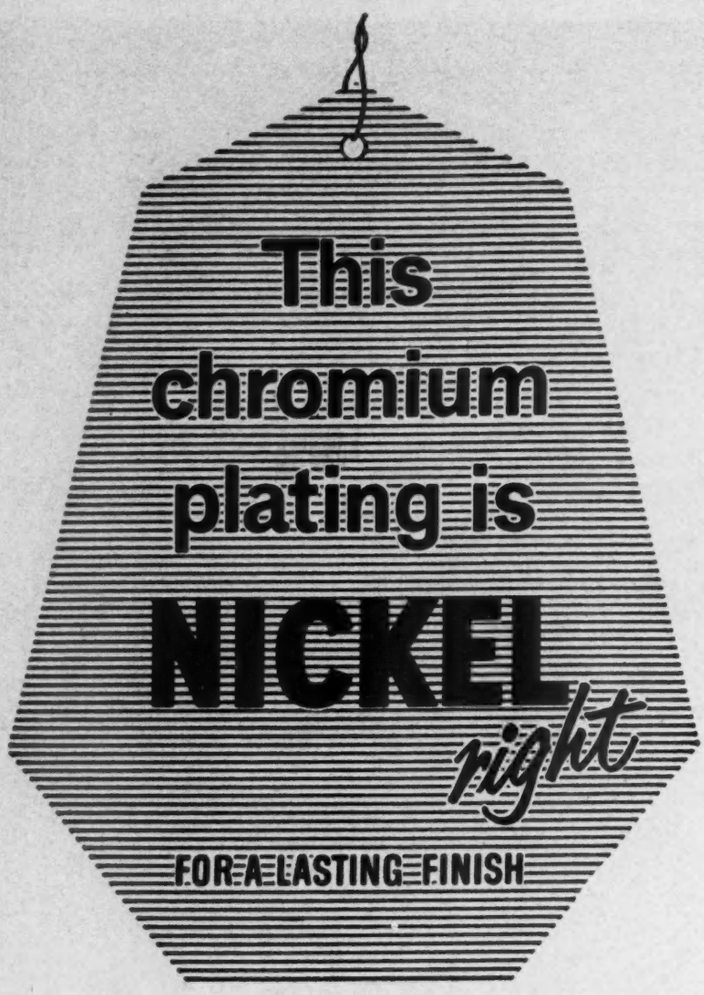

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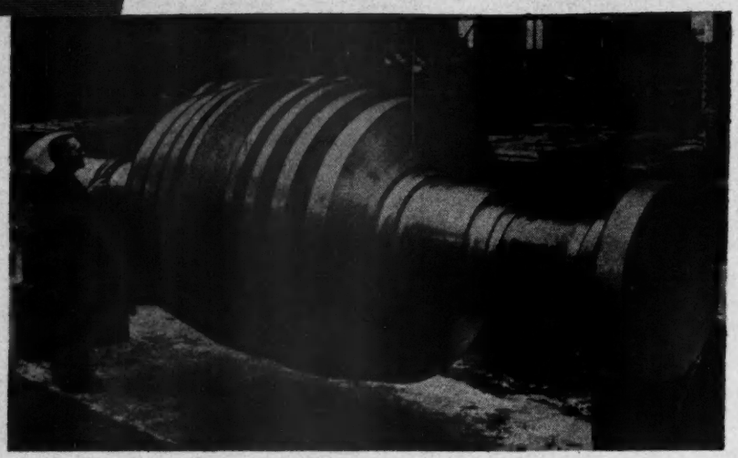
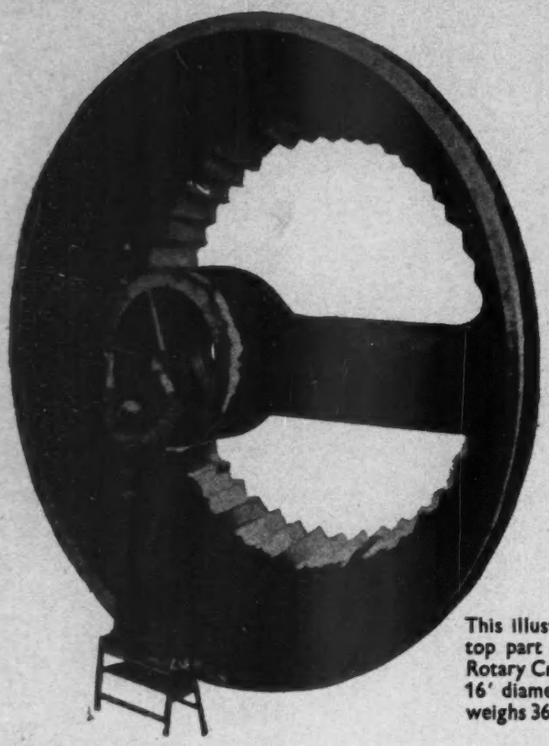
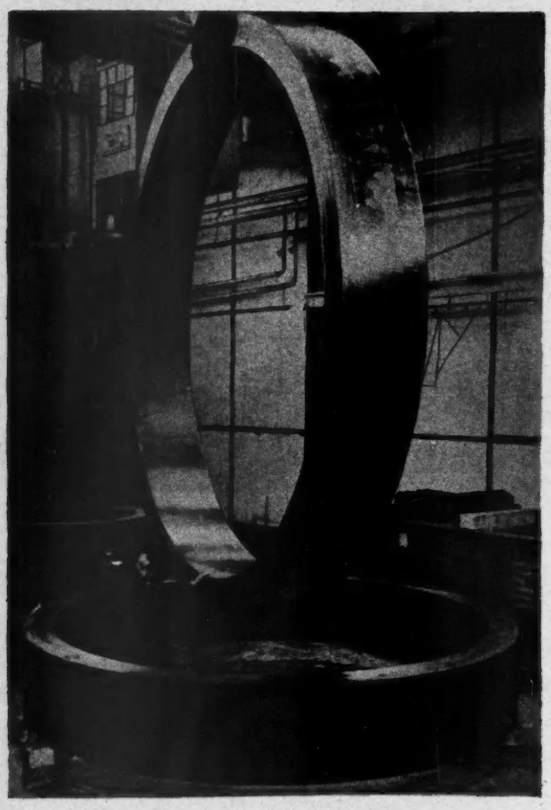


Shown above is a Forged Turbine Shaft of Nickel Chrome Molybdenum special steel rough turned and trepanned. This shaft for a Steam Turbine is 17′ long, the largest diameter 58″ and the smallest 14″, weight 19 tons.

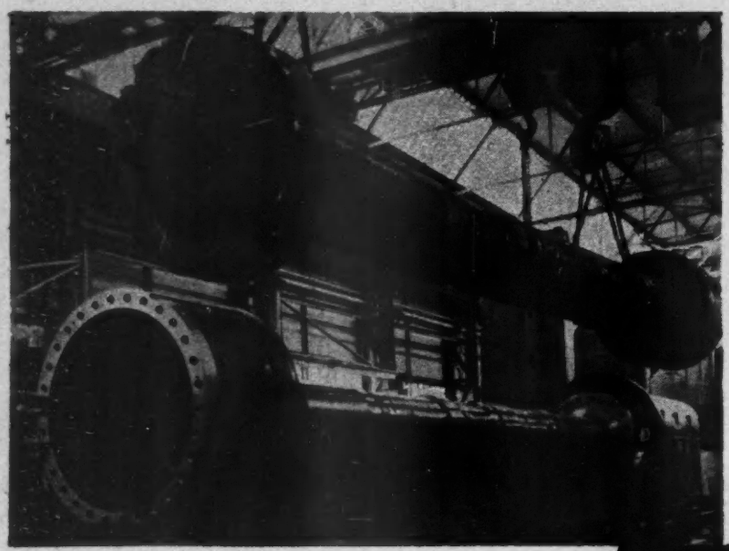


This illustration shows the top part of the Shell for a Rotary Crusher in cast steel 16′ diameter and 7′ high it weighs 36 tons 3 cwt.



The illustration above shows a Cast Steel Tyre 17′ 4″ dia. × 29½″ deep, weight 25 tons. Ruhrstahl also specialise in Rolling Mill Sections for flat rings, angle rings, etc., in a wide range of standard sizes and shapes, full details available on request.

The forged Turbine Shaft shown below in the process of manufacture is made of open hearth steel. The largest diameter is 78″, diameter of flange 68½″ and diameter of shaft 41″. The total length is 41′. Weight finish machined is 47 tons 4 cwt.



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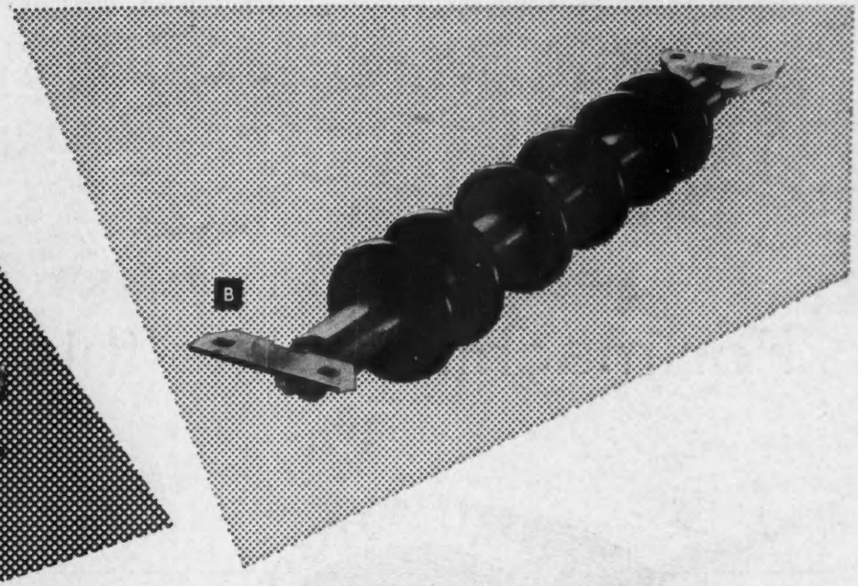

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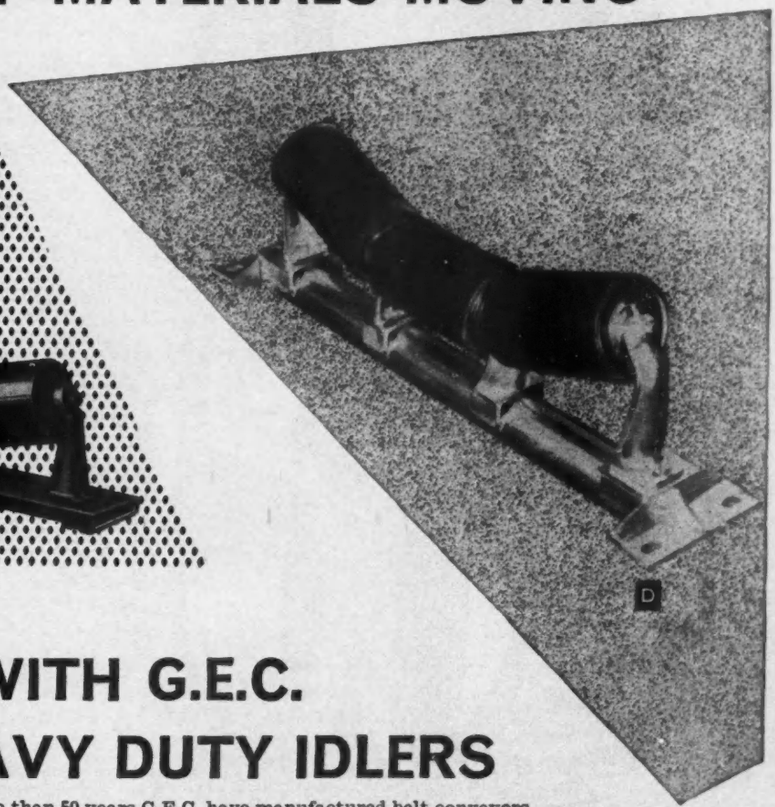

A *6" diameter steel tube troughing idler and return idler.* Rollers are made from mild steel tube 6" outside dia. and 6 s.w.g. Strong, rolled section steel idler base board. All troughing idlers, except on reversible belts, provided with tilting blocks to aid training of the belt.

B *7½" diameter rubber disc return idler.* Tube carrying discs is solid drawn 6 s.w.g. and 3" outside dia. Discs are strengthened internally with mild steel ring and remain rigidly in position. Idler especially suitable where damp and sticky materials are handled.

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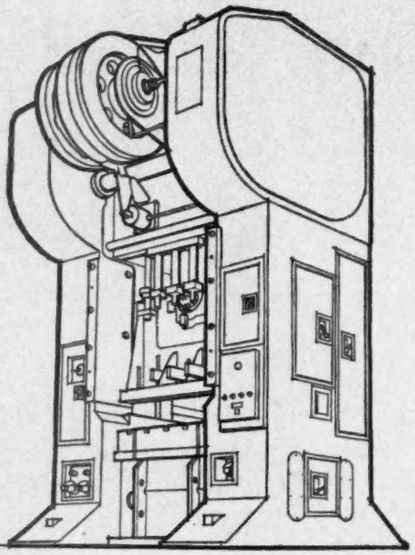

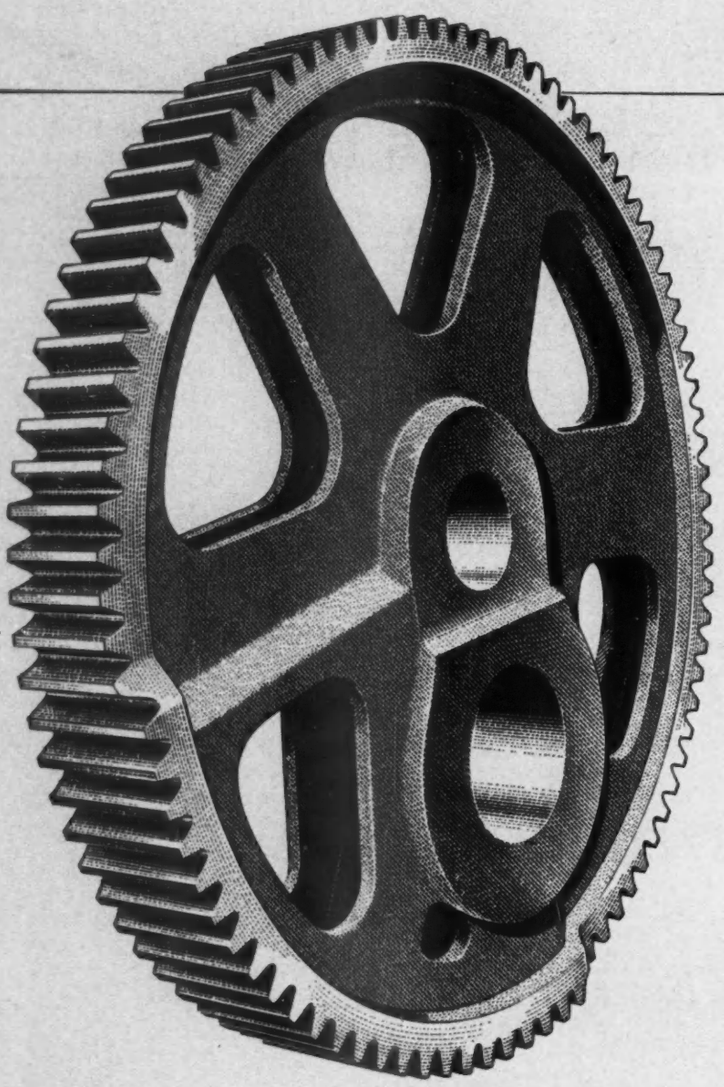

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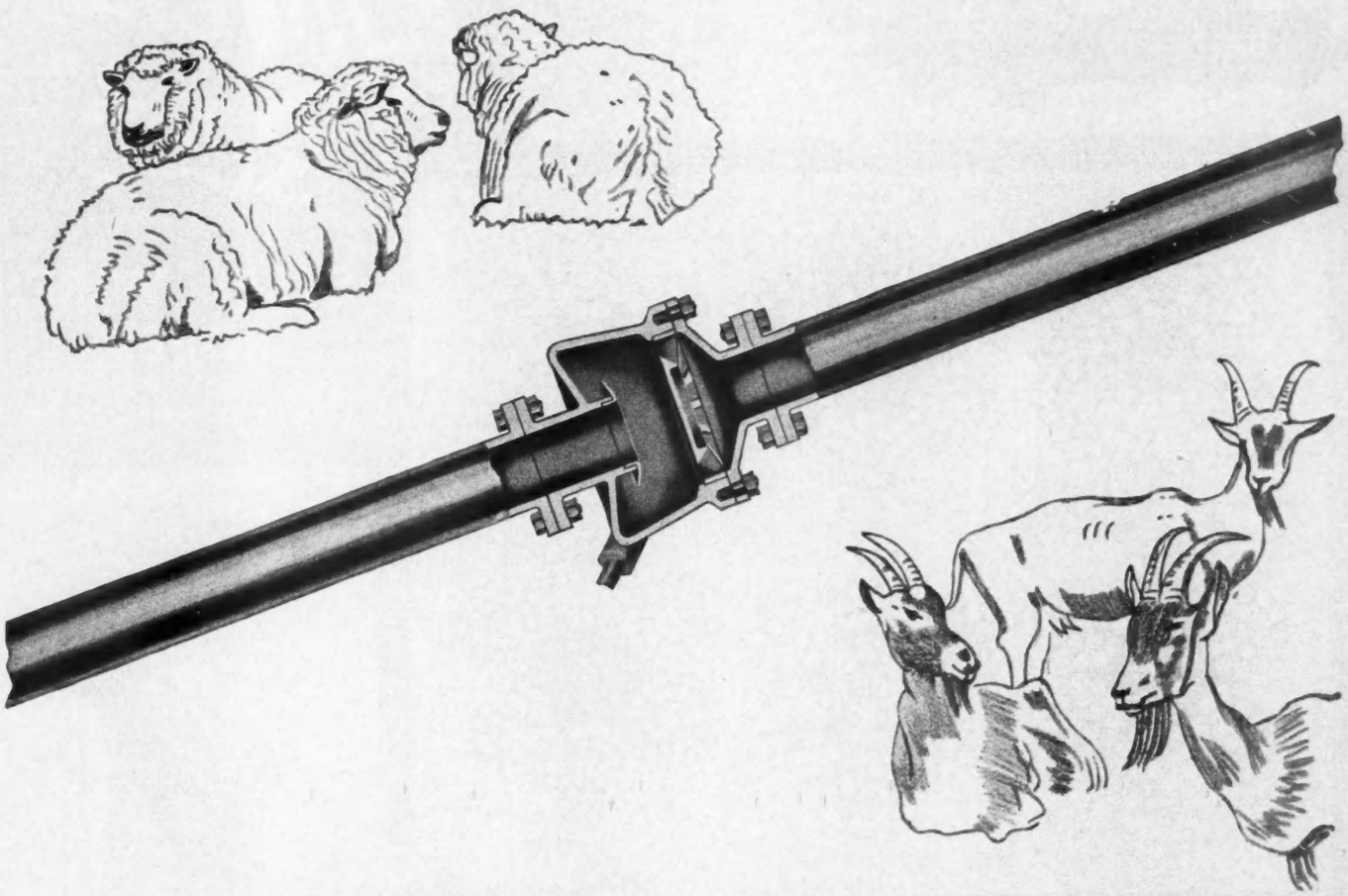

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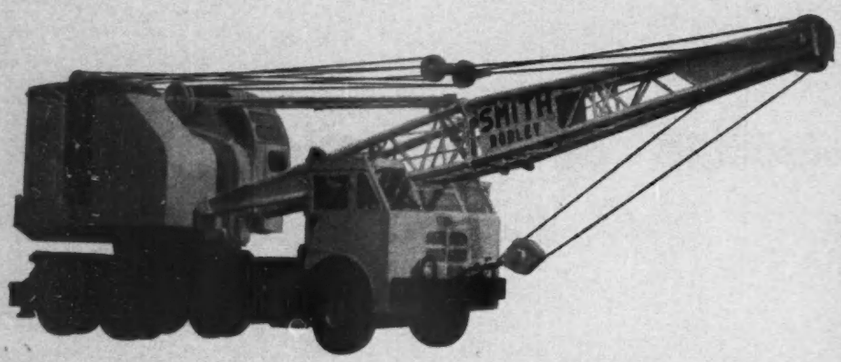

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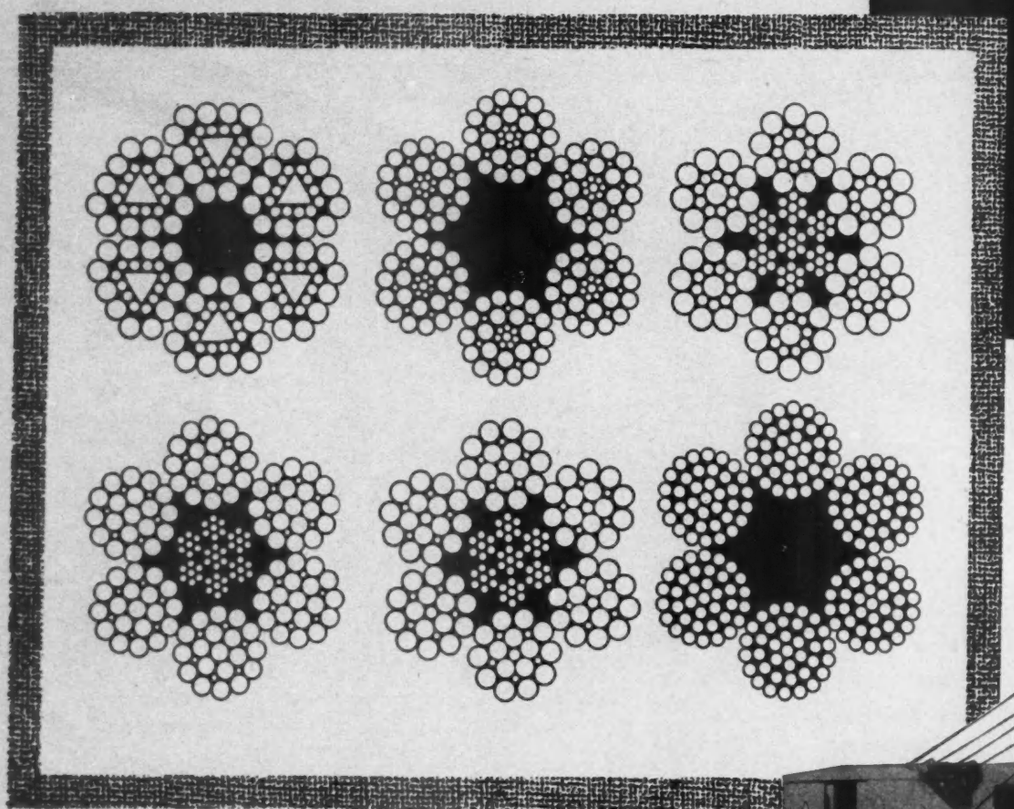

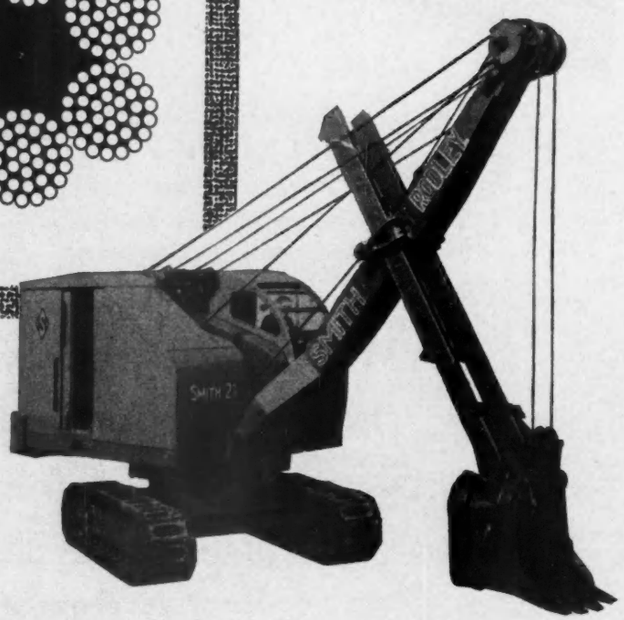

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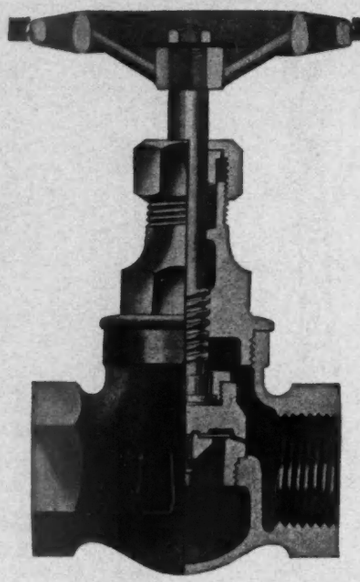

the Fig. 2016
'PRESEATOR'
globe valve
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Flexible Titanium Disk*

This specially designed Hattersley valve incorporates a flexible pre-seating disk made of an I.C.I. titanium alloy which is exceptionally resistant to corrosion and erosion. As this seats before the main surfaces, pipe-scale is trapped and the main seating surfaces protected from the effects of wire drawing.

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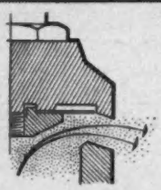
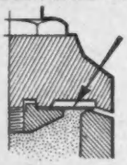
* *The Flexible Titanium Disk is protected by Patent No. 822147*

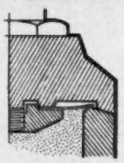
Over a period of years the outstanding merits of this Valve have been proved under the most arduous service conditions on many installations.



In open position free passage for flow directed across seating surfaces.



In 'Pre-shut' position flow and pipe scale held back by *Flexible Titanium Disk*. Patent No. 822147



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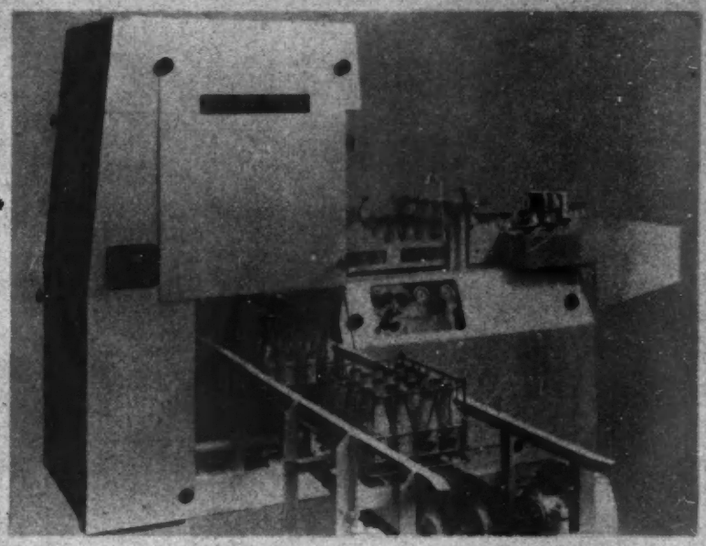

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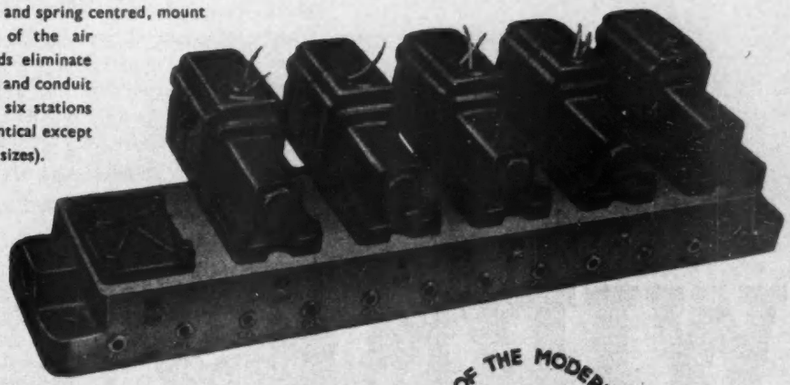

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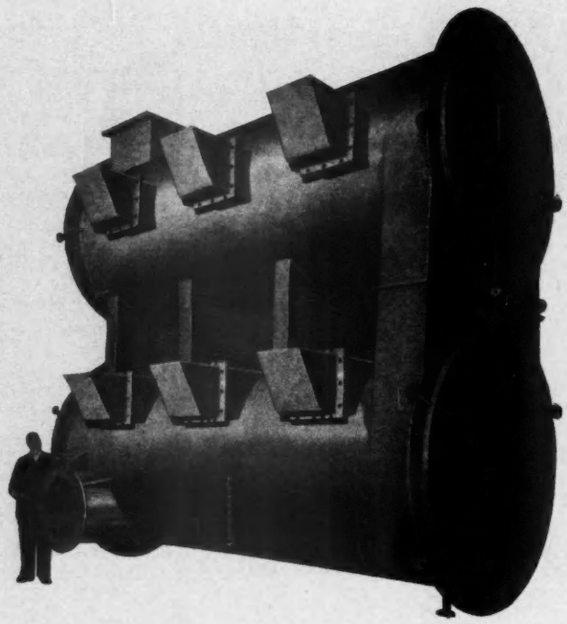

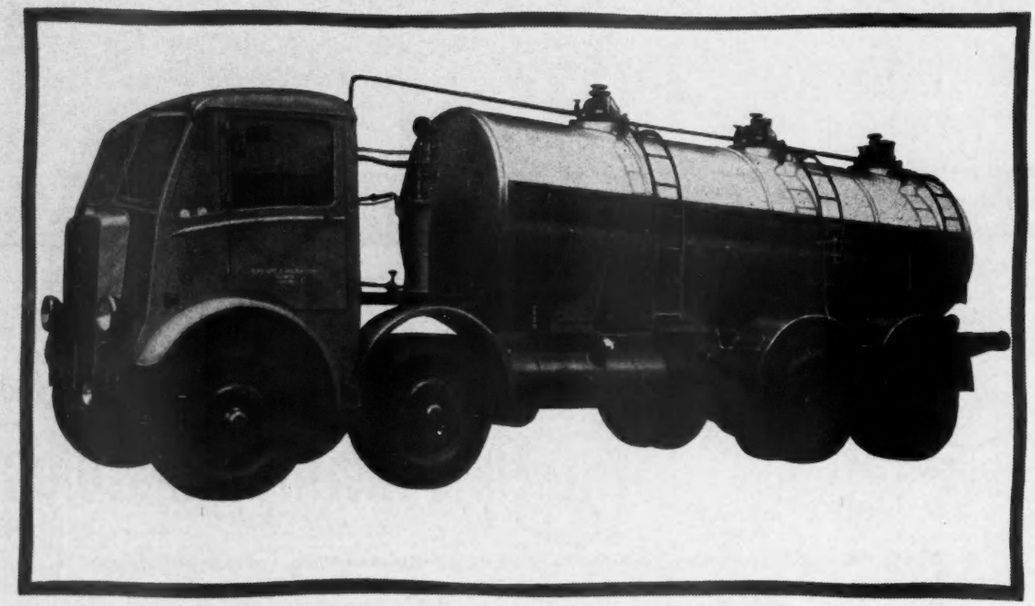

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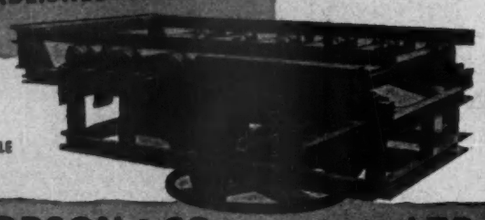

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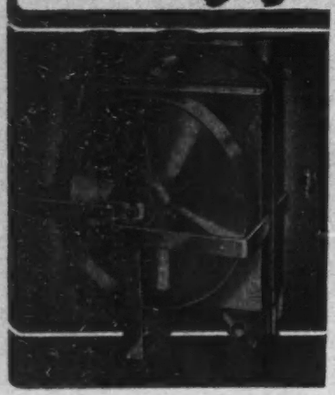

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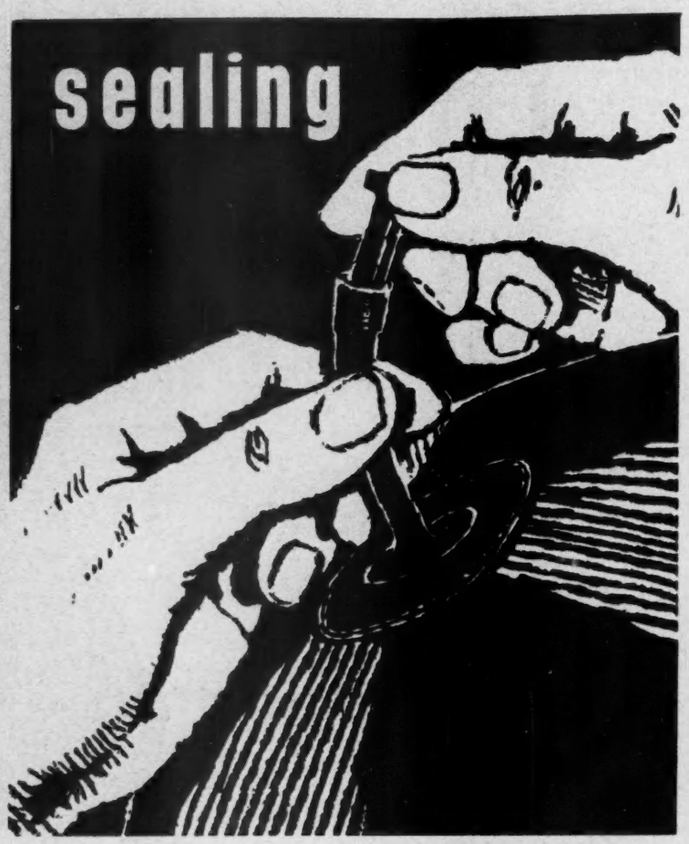

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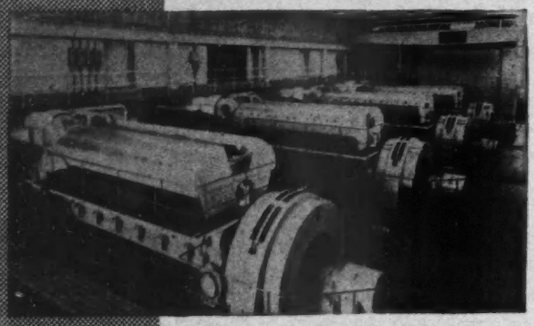

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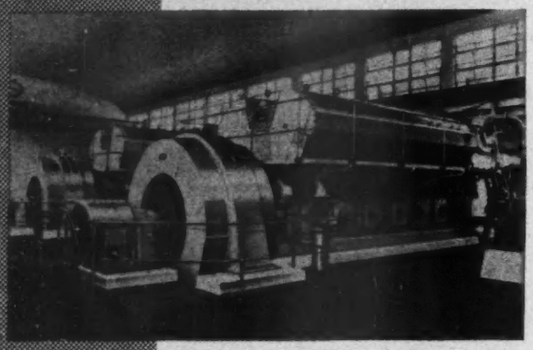

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MG 4

Cross-shaft, as supplied by Keetons, for the 'Tiger' V-X Excavator

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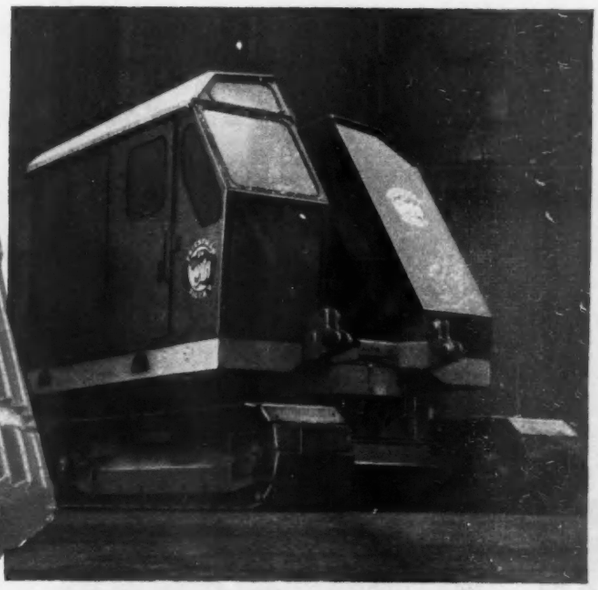
These hollow bored bars are produced by Keetona deep hole drilling for Priestman excavators. Deep hole drilling is quite the most economical boring process available. However small your order, or however tricky, depend on Keetons to do a low-priced job *every* time. To save you subsequent costly machining, Keetona Hollow Bored Bars are now available finished bored and honed in a range of bores from 2″ to 8″. A new illustrated booklet gives full details. Please write for your copy.



Vertical travelling shaft. Hollow bored bar supplied by Keetons and processed by Priestman Brothers Limited.

TRADE KEETONA MARK

HOLLOW BORED BARS

KEETON SONS & CO. LIMITED,
KEETONA WORKS, GREENLAND ROAD, SHEFFIELD, 9. TEL: SHEFFIELD 42961/4

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impalco extrudes, rolls, draws and fabricates aluminium and aluminium alloys.

impalco delivers from stock the shapes and sizes most in demand by British users.

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All Reyrolle products are backed by highly organised research and development facilities to ensure the excellence of performance for which they are noted

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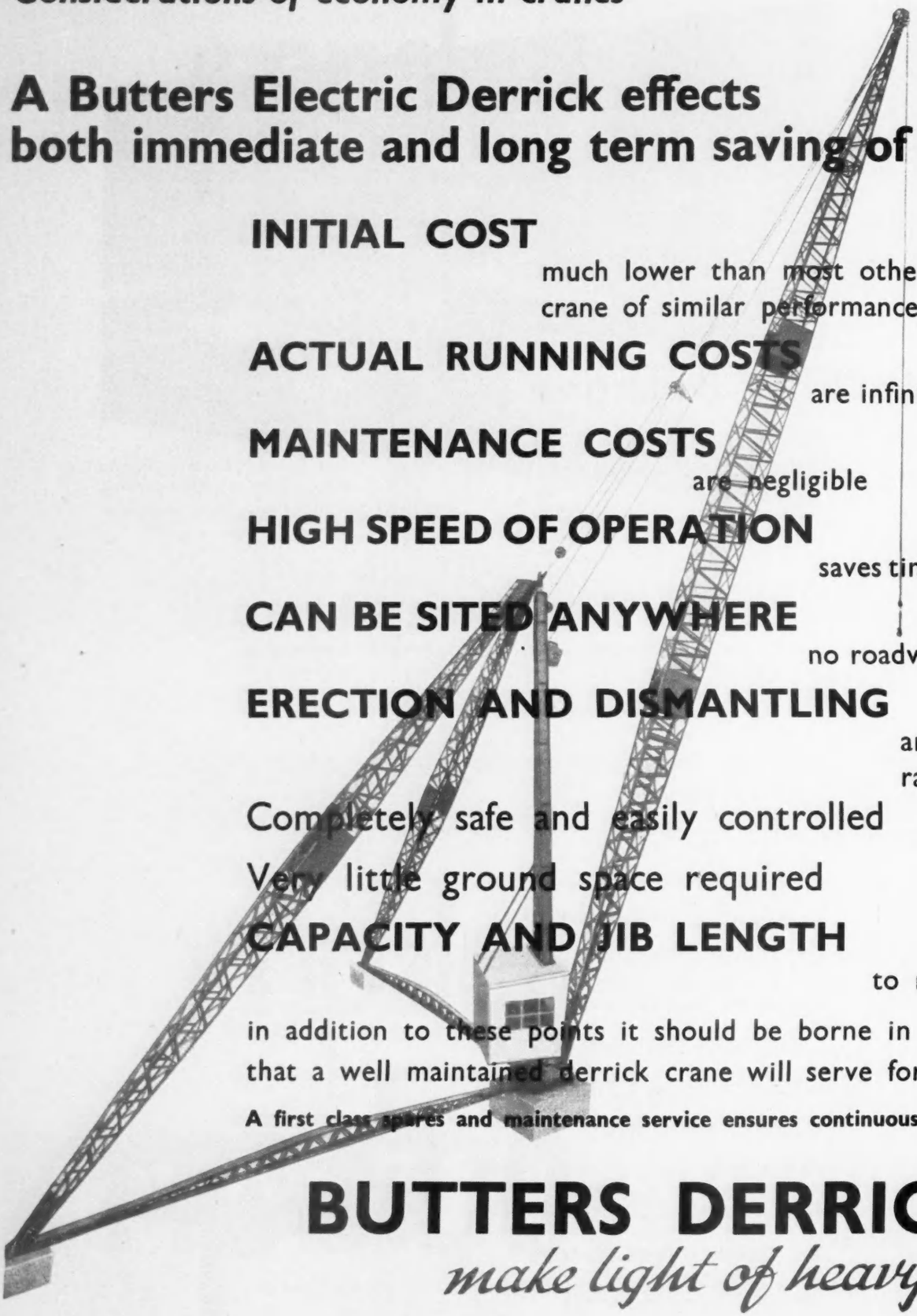
Considerations of economy in cranes

A Butters Electric Derrick effects both immediate and long term saving of cost



INITIAL COST
much lower than most other types of crane of similar performance

ACTUAL RUNNING COSTS
are infinitesimal

MAINTENANCE COSTS
are negligible

HIGH SPEED OF OPERATION
saves time and money

CAN BE SITED ANYWHERE
no roadways required

ERECTION AND DISMANTLING
are simple and rapid

Completely safe and easily controlled

Very little ground space required

CAPACITY AND JIB LENGTH
to requirements

in addition to these points it should be borne in mind that a well maintained derrick crane will serve for many years

A first class spares and maintenance service ensures continuous operation

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make light of heavy loads

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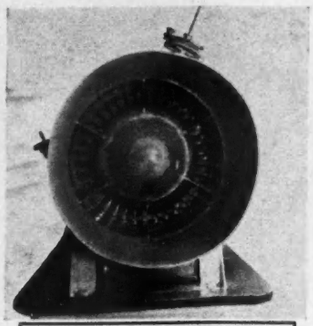
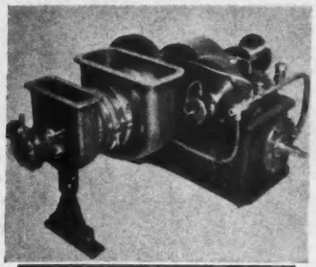
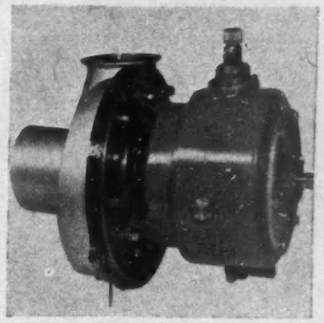
LONDON: THE CRANE WORKS, LONG LANE, HILLINGDON, MIDDLESEX, AND AT BIRMINGHAM & NEWCASTLE



Axial Flow Air Compressor

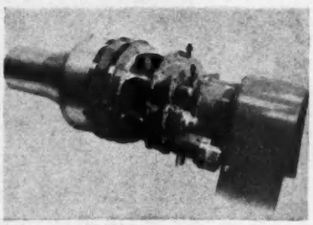


350 H.P. Turbine for Gasifier

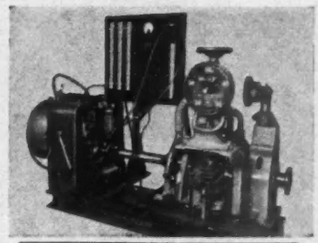


Radial Flow Free Power Turbine

GAS TURBINE DRIVEN MACHINERY



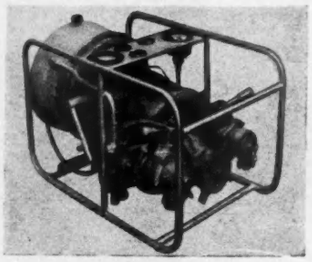
500 H.P. "Basilisk" Gas Turbine (Shaft Power and Air Bleed versions)



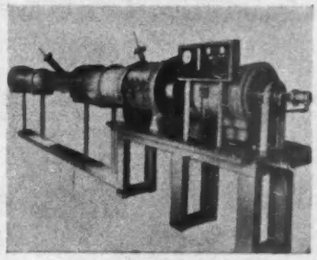
Instructional and Test Set

AXIAL AND RADIAL FLOW AIR COMPRESSORS

500 G.P.M. Lightweight Pumping Set



Axial Flow Compressor for Instructional Use



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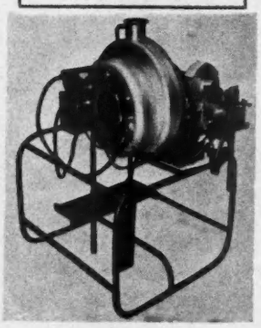
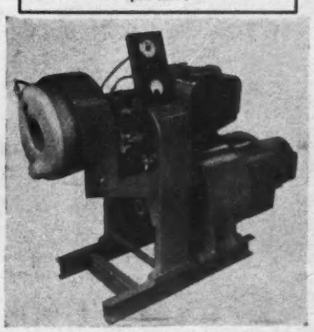


Generating Sets up to 400 kW.



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K2

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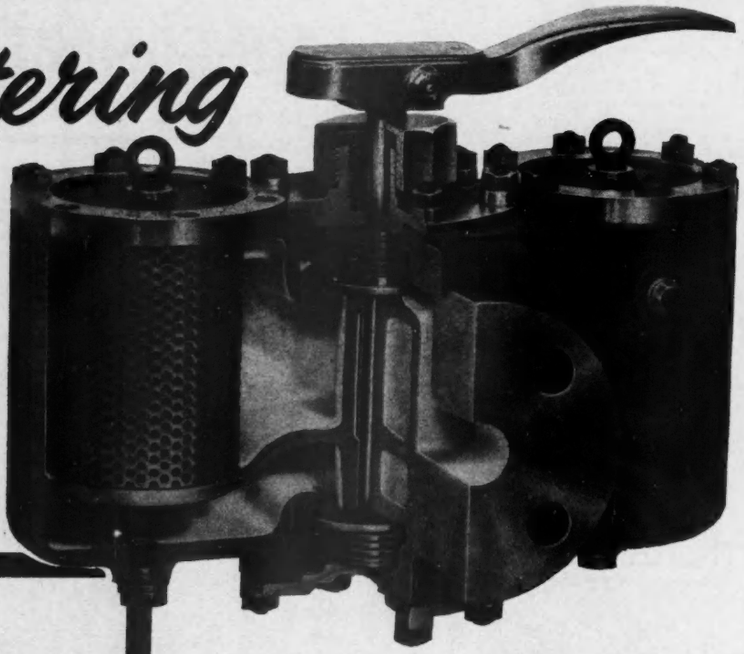
way!

There is a complete range of Zwicky filters, single and dual gauze and the self cleaning Zwikleen, each with its own specific function. We are always happy to advise on their suitability to any particular problem.



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HIGH PRESSURE FUEL PUMPS
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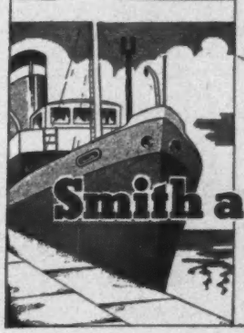

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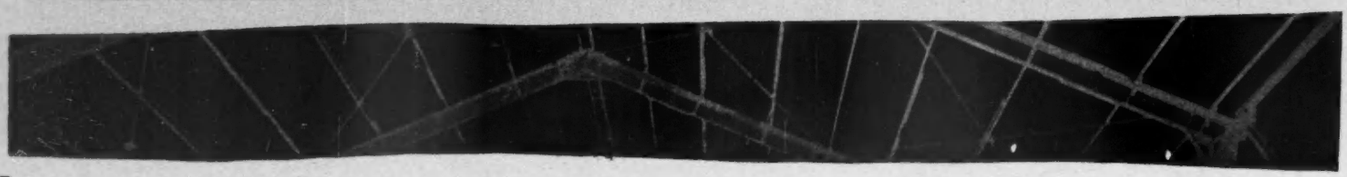
• DESIGN •

The Portal Roof...

• ERECTION •



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. . modern construction for the modern factory . . . .

Ever in the forefront of modern development, Lambhill show this example of a welded Portal Roof—a twin—span construction with spans measuring 70 ft. by 500 ft. giving maximum unobstructed headroom. There are no members below the rafter line to accumulate dust and dirt; the construction permits easy complete insulation. Maintenance costs are low.

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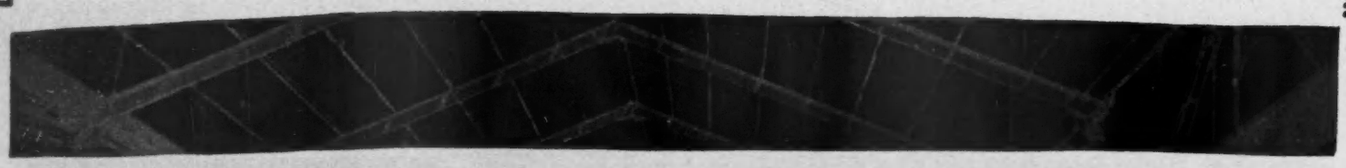

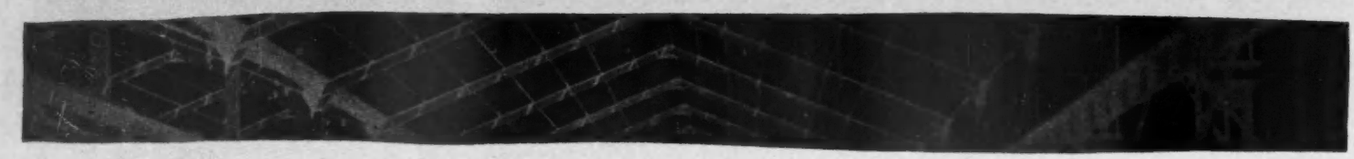

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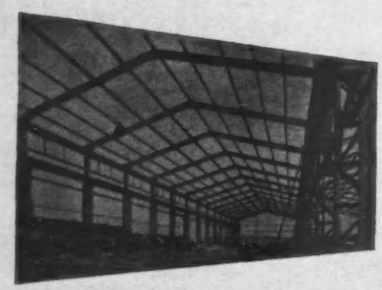

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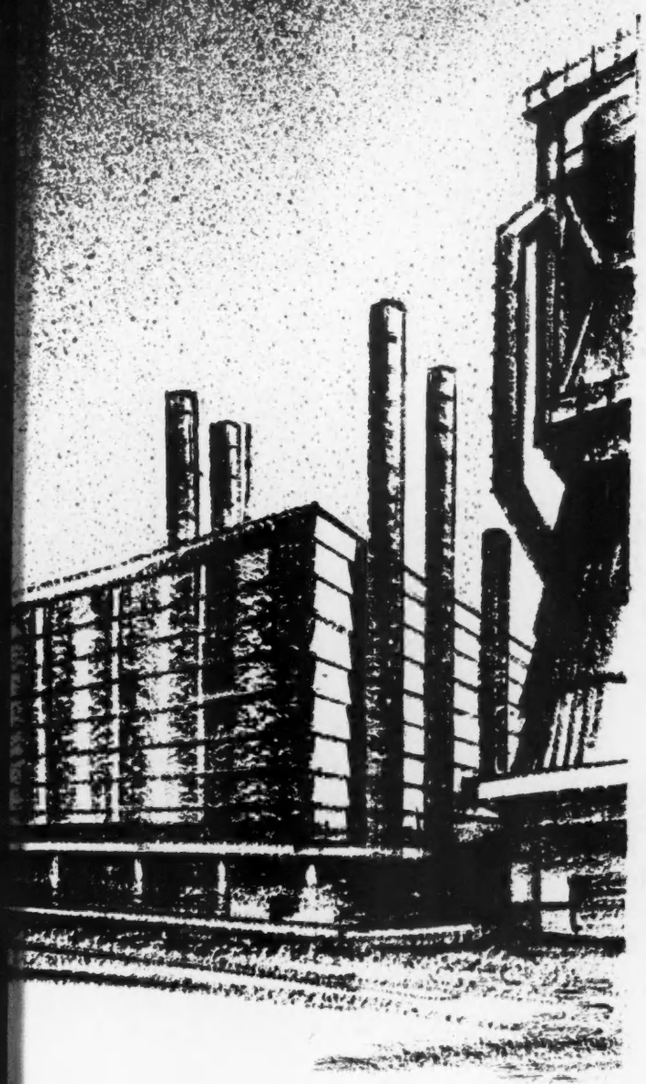

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PARSONS turbo-blowers & turbo-generators

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"Pure" water never occurs

Whatever the source, water always contains salts in solution and often matter in suspension.
John-Thompson-Kennicott supply plant for the treatment of cooling waters, and for boiler feed requirements, Kennicott De-ionisation and De-aerator installations are working in all parts of the world.
Contracts for De-ionisation Plant placed with John Thompson-Kennicott Ltd., by the Central Electricity Generating Board include:
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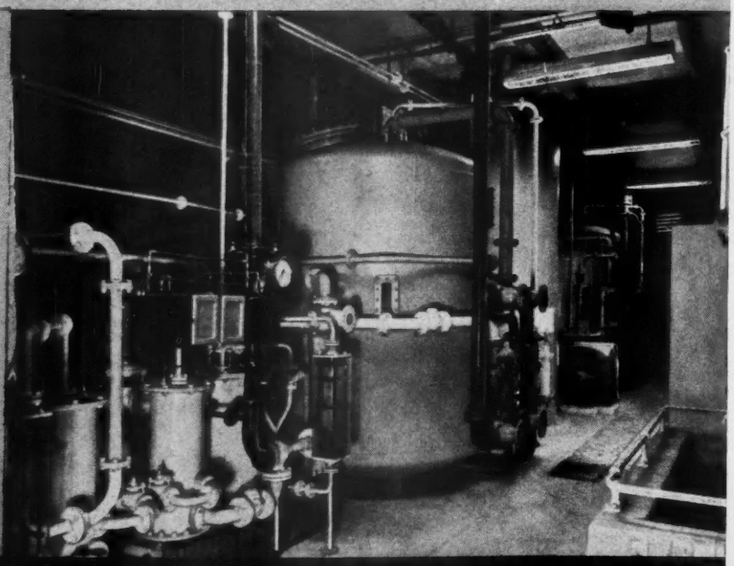
** The illustration shows de-ionisation plant at North Wilford Power Station producing 75,000 gallons of treated water in 14 hours for high pressure water tube boilers.*



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H.D.A. are unlikely to be disconcerted

The making of these components demanded a material combining outstanding formability with great strength. Fortunately for all concerned, the manufacturer took the problem to H.D.A., who evolved special treatments for one of their Hiduminium Sheet Alloys which gave it exceptional properties for deep pressing and spinning operations.
Out-of-the-way problems of this sort are, as you may suspect, only too common.
May we suggest that it is better to take them to H.D.A. at once rather than eventually?
H.D.A.'s sleeves are always rolled up. Their thinking-cap is always on.

Hiduminium makes the most of *Aluminium*

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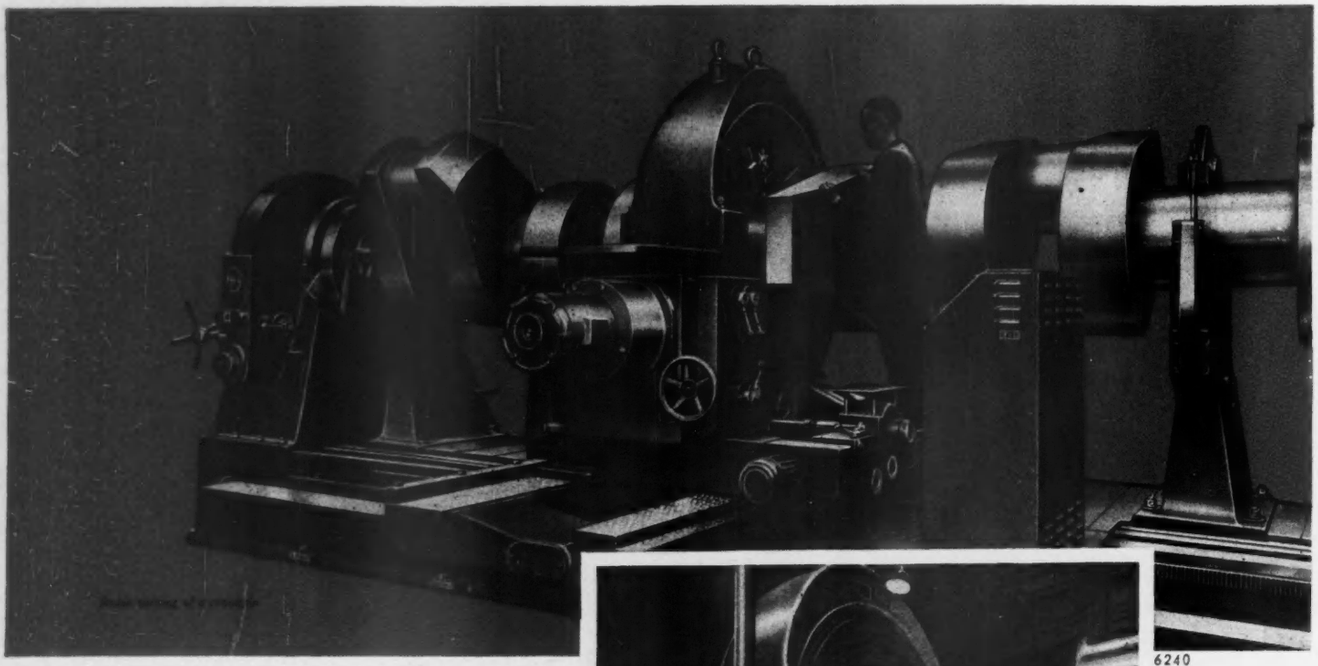
Spinnings & pressings in Hiduminium by Argonarc Engineering Ltd.

SCHIESS

Crankpin Turning Machine

For the finish turning of crankpins

up to 900 mm diameter



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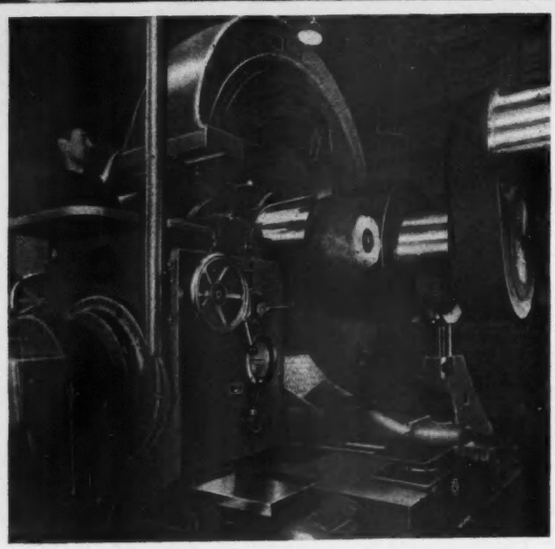

Removing the top half of the revolving ring assembly after finish turning of a crankpin

High Precision

with even the largest crankshafts
—finished roundness well within 0.015 mm and
—cylindricity well within 0.015 mm over a length of 400 mm

Due to

the rigidity imparted by the low height of the machine, the revolving ring of which has a diameter only slightly larger than the maximum crankpin diameter, since the crank webs do not have to be passed through the ring

the crankshaft being supported during machining in a way similar to its subsequent mounting in an engine

only one loading being required for machining all crankpins.

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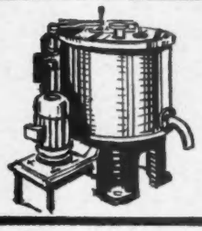
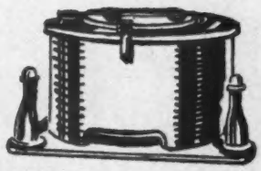
BROADBENT CENTRIFUGES FOR THE CHEMICAL INDUSTRY

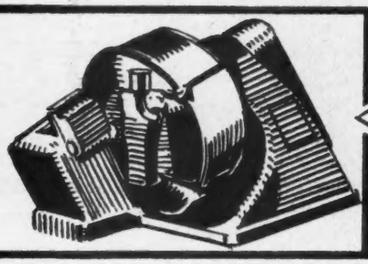
ref. J.6



21″ 30″ AND 36″ BASKET DIAMETER
BATCH TYPE CENTRIFUGES
(for pharmaceuticals)

SUSPENDED UNDERDRIVEN CENTRIFUGES
(with or without mechanical discharge)





INCLINED CENTRIFUGES WITH
MECHANICAL DISCHARGE
(automatic features)

60″ HORIZONTAL
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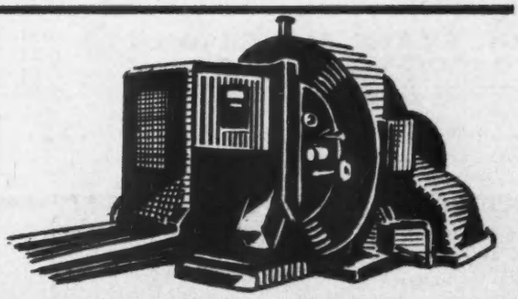
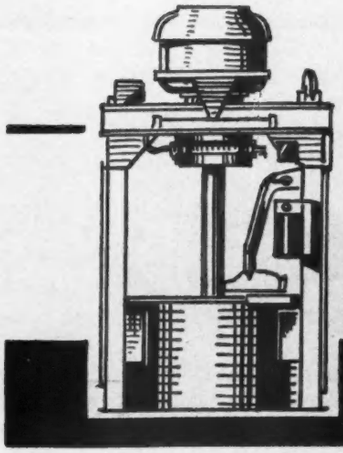
CENTRIFUGES
(automatic)





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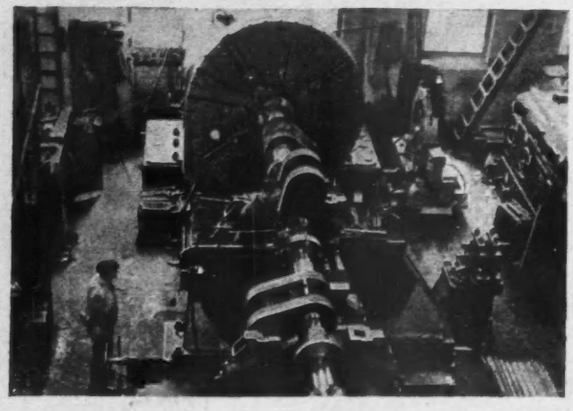
Rough Turned
Finished Complete



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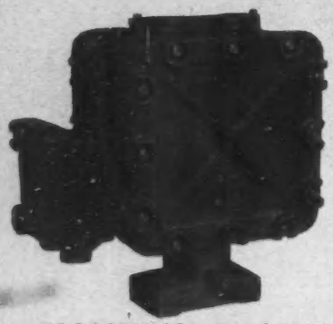

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Continuous rating

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D.C. up to 600 volts

Suitable for operation in most hazardous & dusty atmospheres

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INDUSTRIAL CALICOES AND TEXTILES

FINISHES TO COMBAT ROT, MILDEW, FIRE, FRAY, WATER, ETC.
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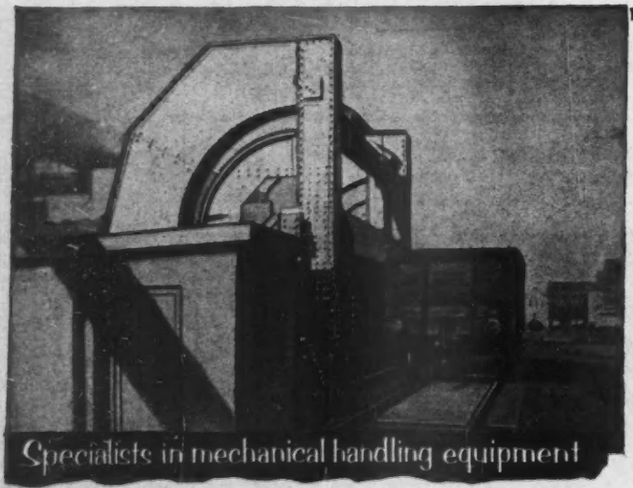

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Wagon Tipplers · Wagon & Skip Hoists
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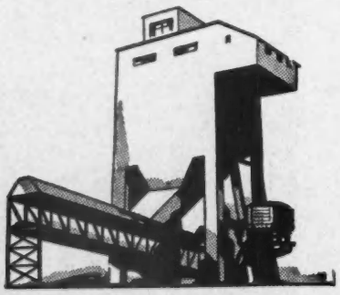

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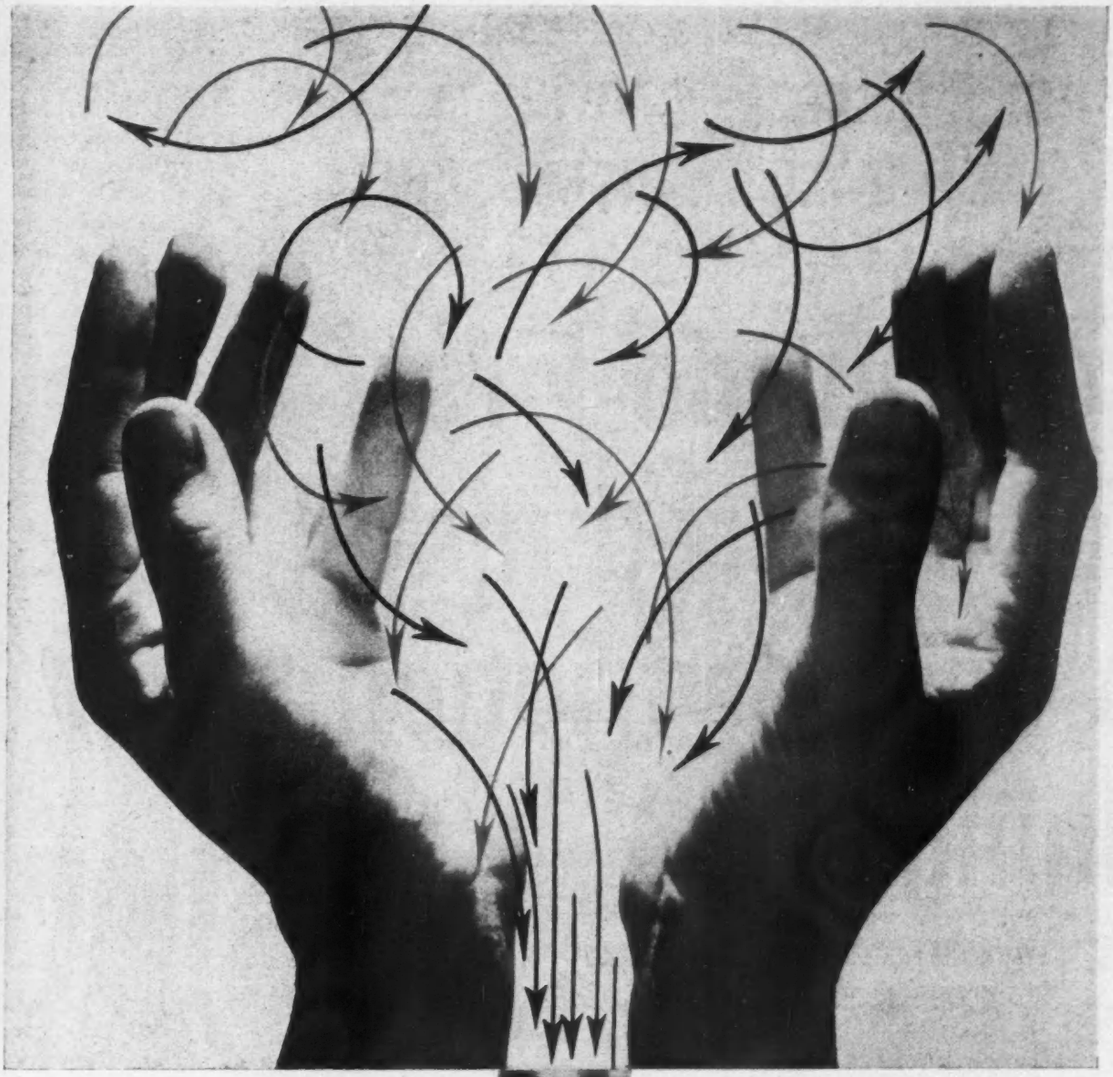

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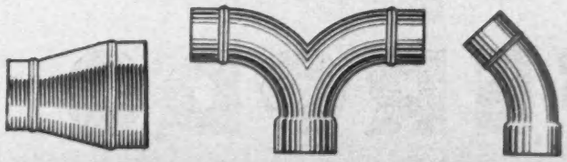

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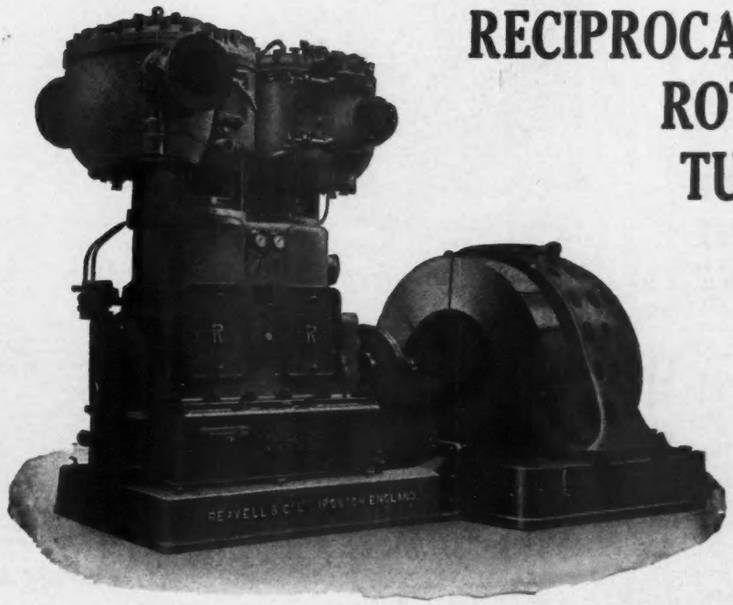

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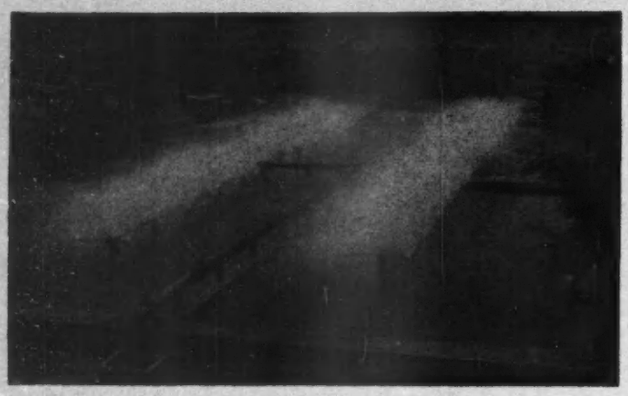

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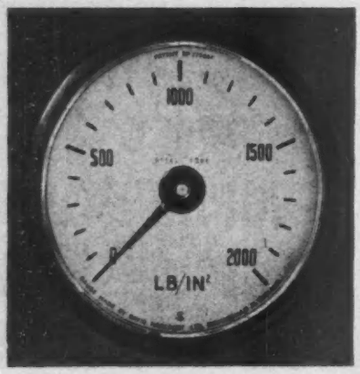

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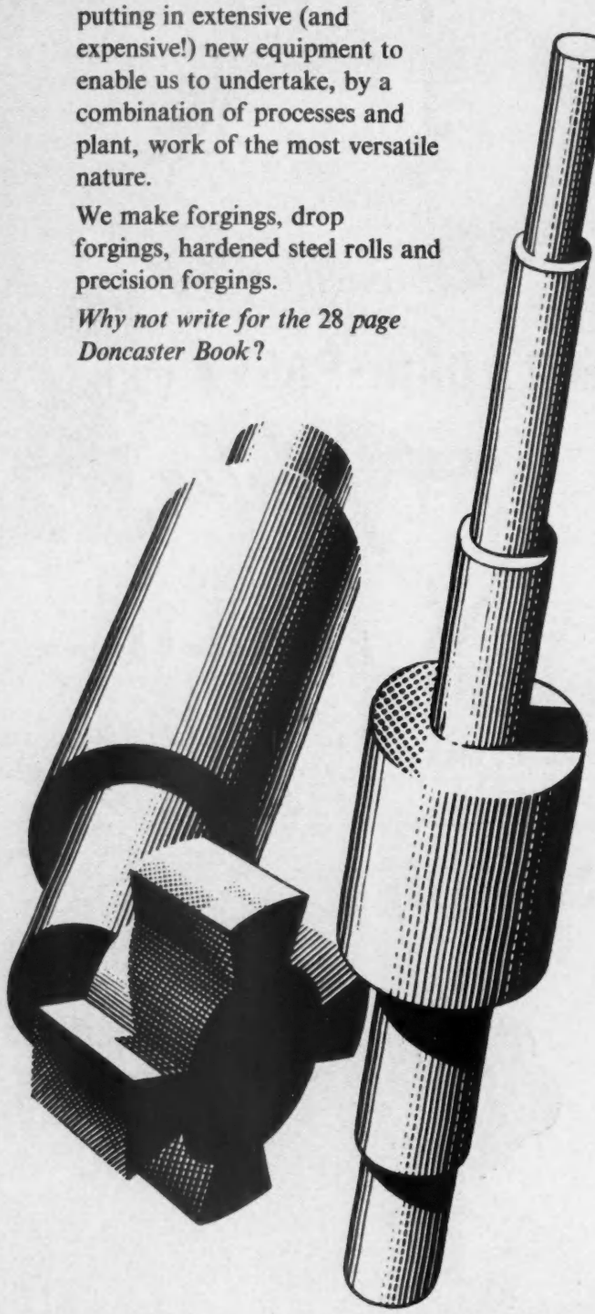

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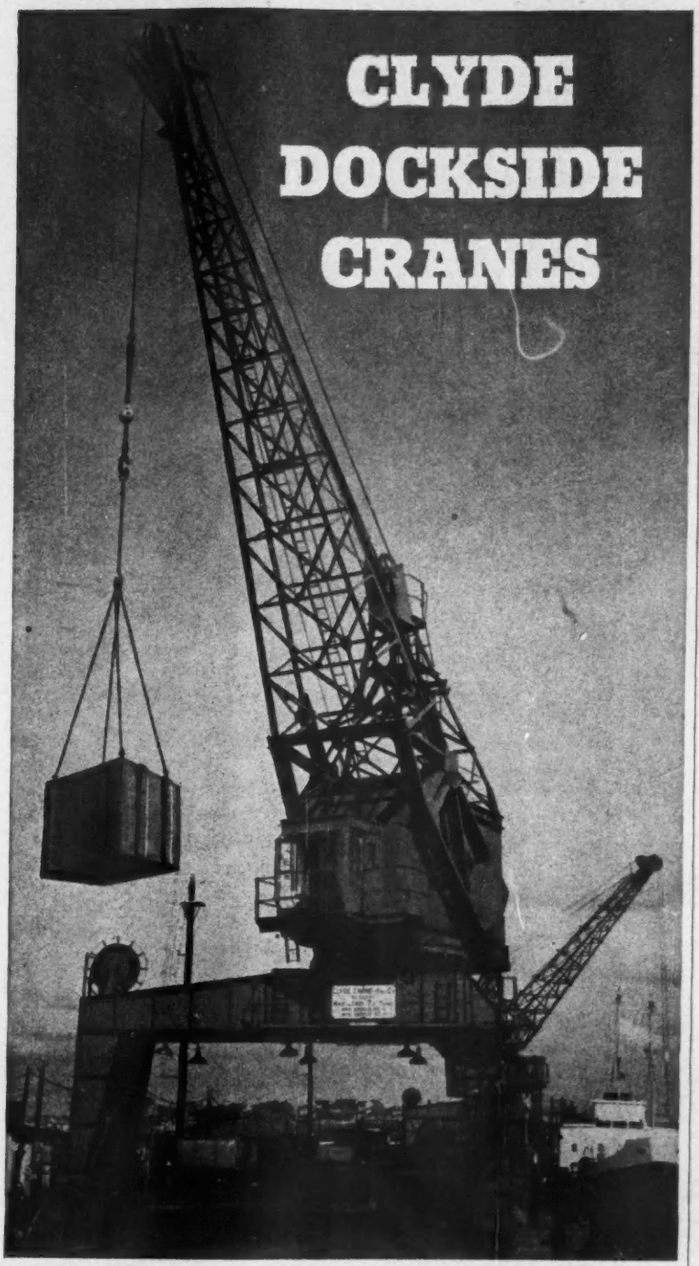

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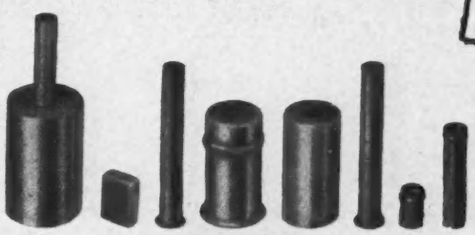

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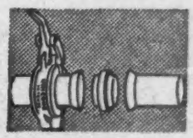
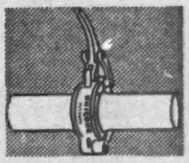
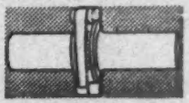


Rubber gasket in position and joint ready to pull over



Pipe ends joined ready for locking



The completed joint

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Flexible Joints for Pipelines

Leakproof. safe. reliable

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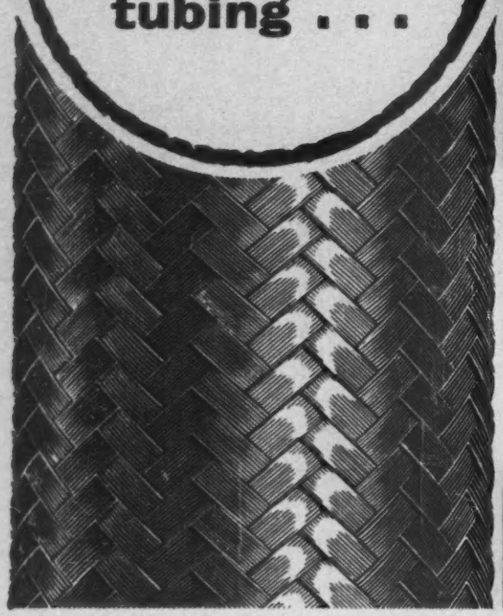

. . . this machine requires 1300 MILES of Austenitic Stainless Steel Wire of any gauge each week

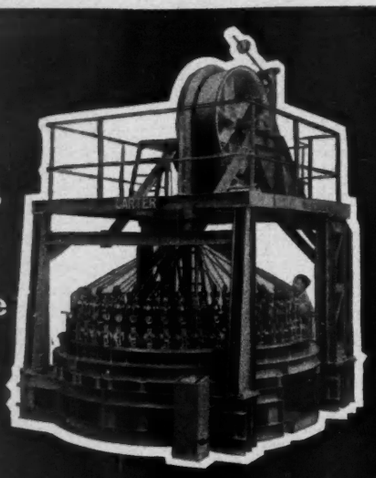

Photo by courtesy of Messrs. B. & F. Carter & Co. Ltd., Bolton, Lancs.

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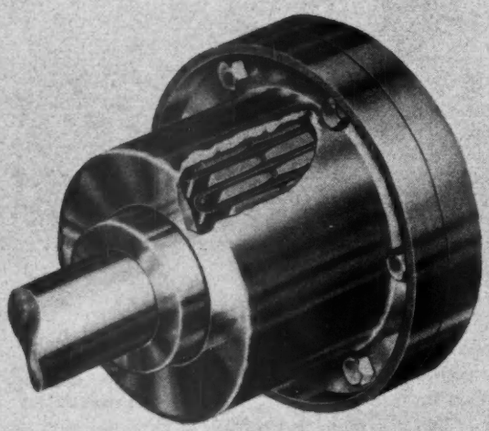

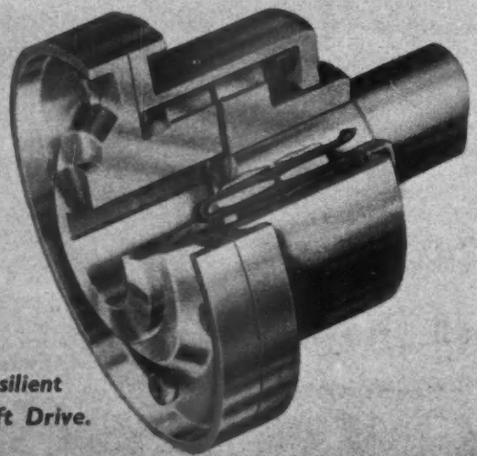

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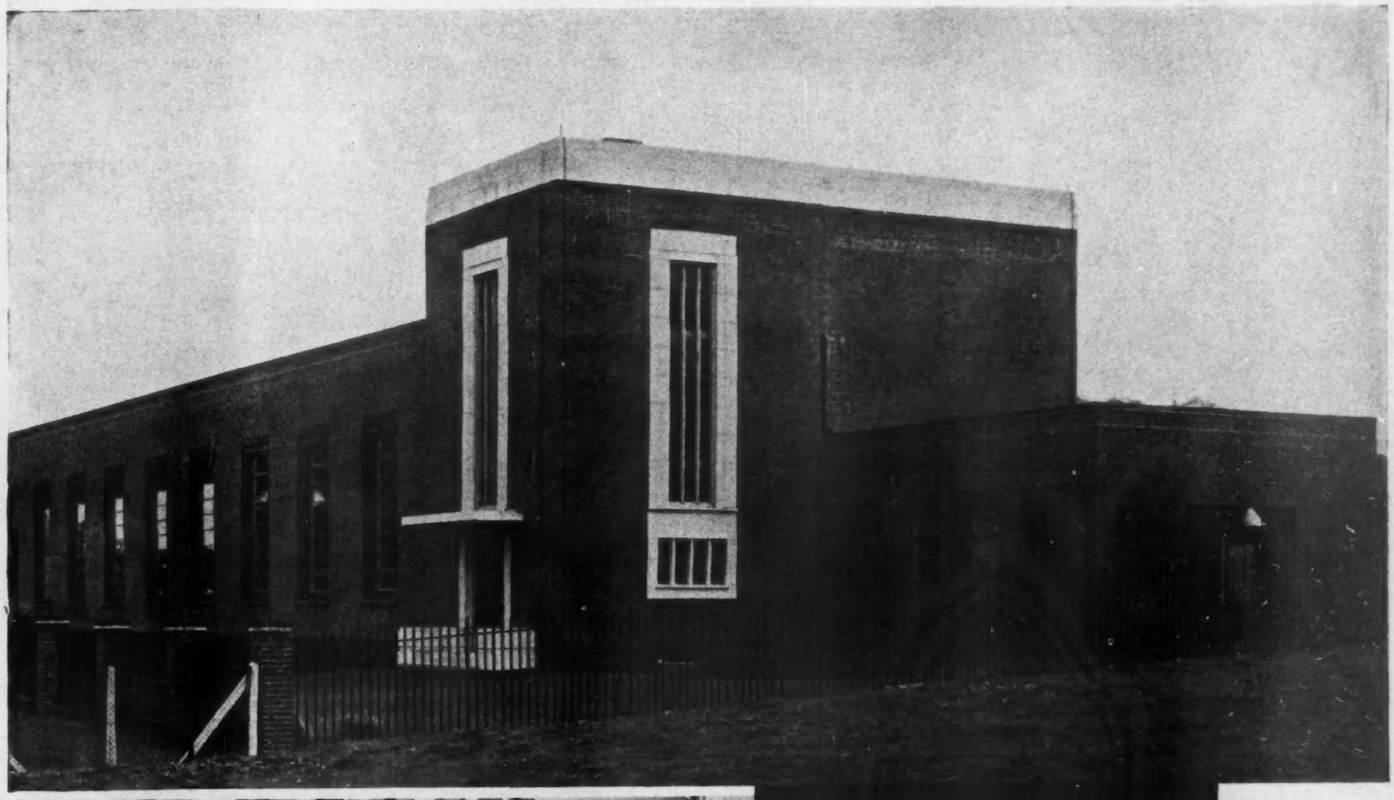

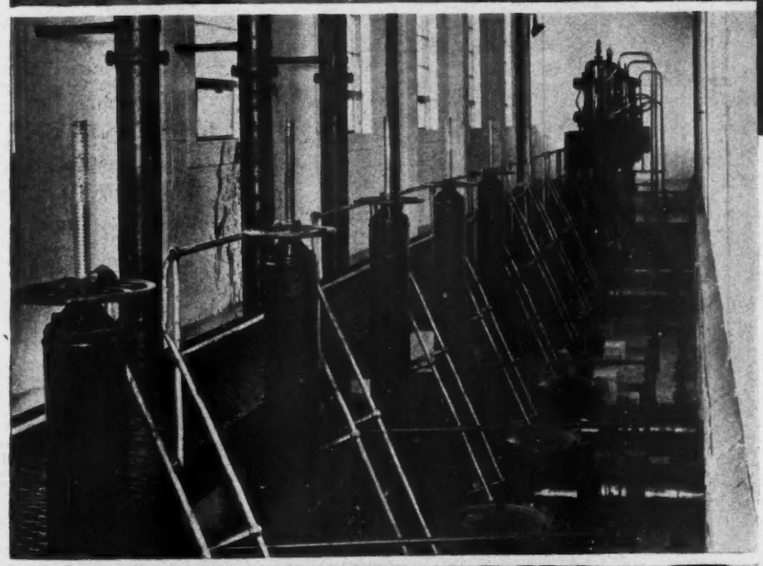

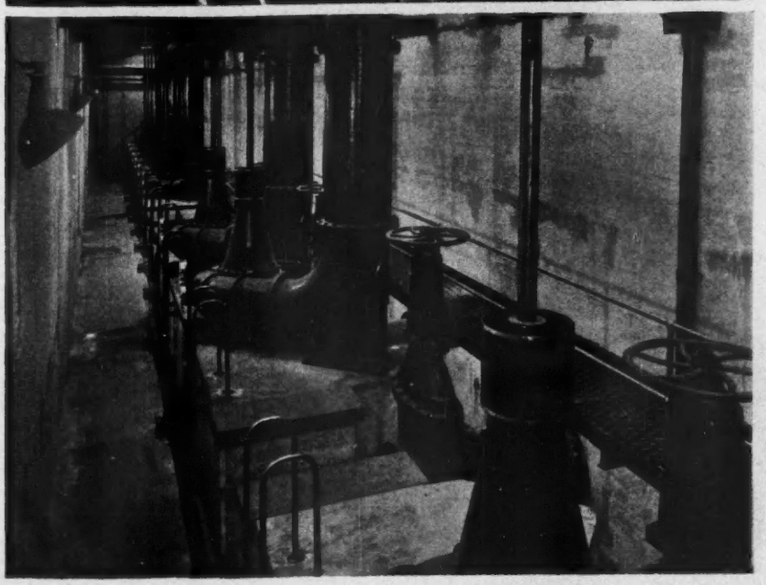

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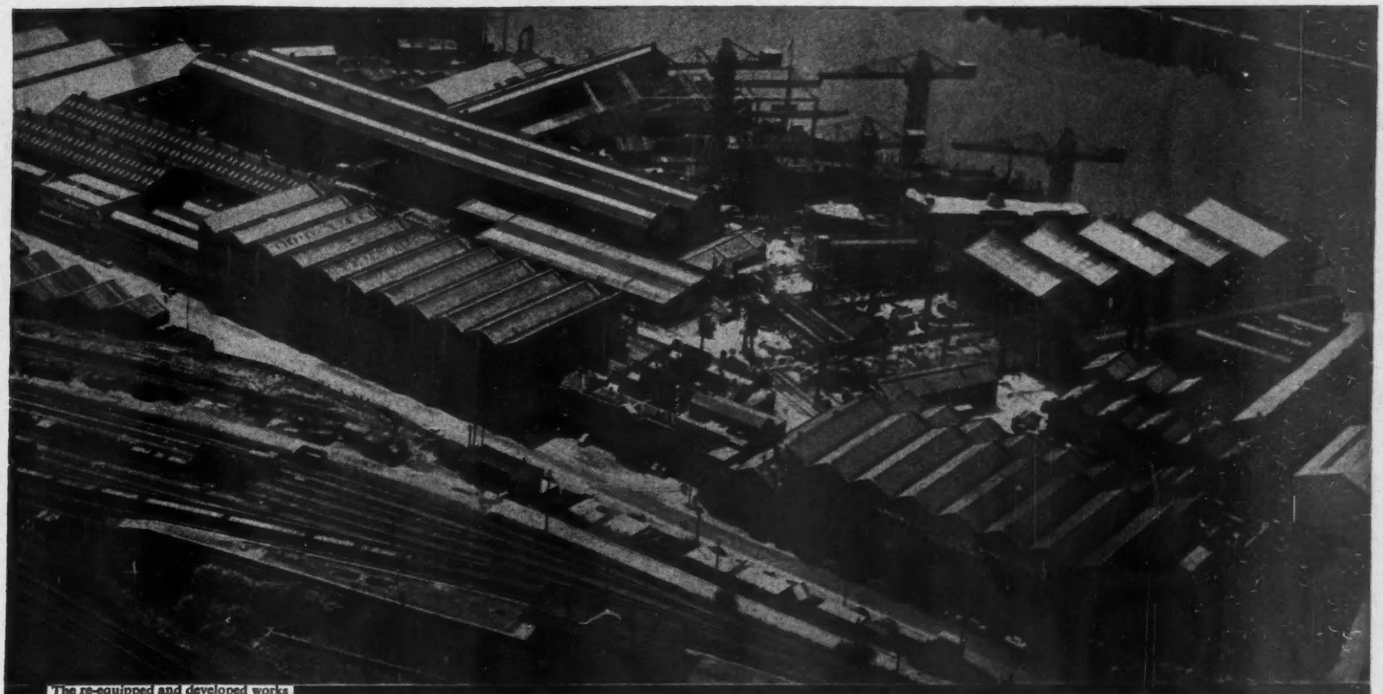

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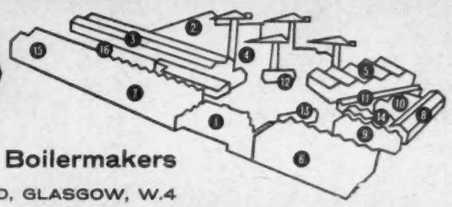

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Such was their success that we are now privileged to supply suspension equipment to the five members of the Nuclear Consortia for the five latest Nuclear Power Stations. A new Genspring capable of supporting 97,800 lb. with a 12" vertical travel has been built mainly for use in Nuclear Power applications.

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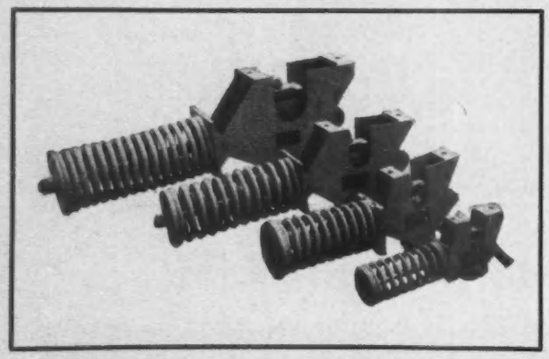

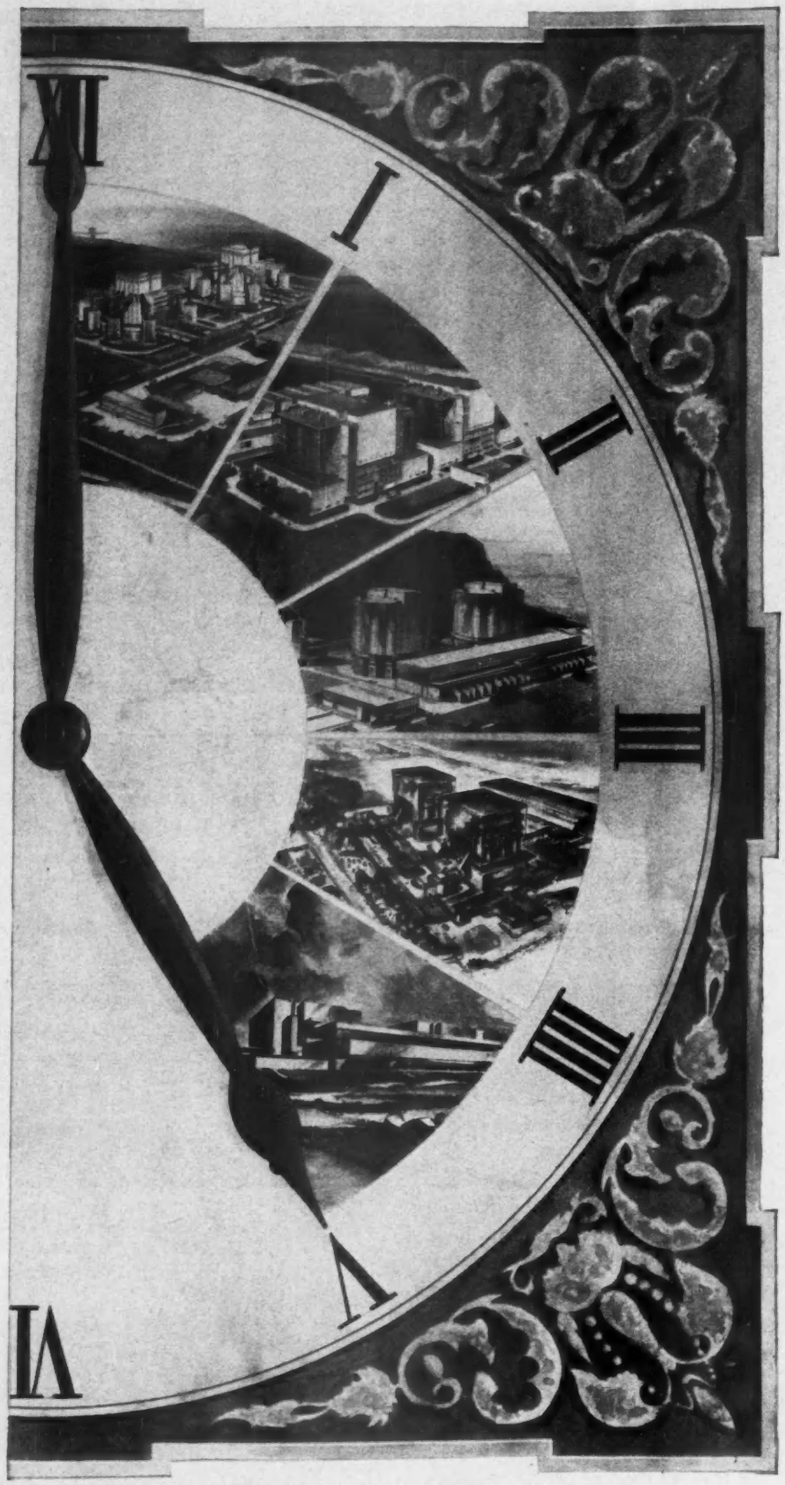

The illustrations above are artists' impressions of the Nuclear Power Stations at Berkeley (A.E.I.—John Thompson Nuclear Energy Co. Ltd.); Bradwell (The Nuclear Power Plant Company Ltd.); Hunterston (G.E.C.–Simon-Carves Group); Hinkley Point (English Electric, Babcock & Wilcox, Taylor Woodrow Atomic Power Group) and Trawsfynydd (Atomic Power Constructions Ltd.)

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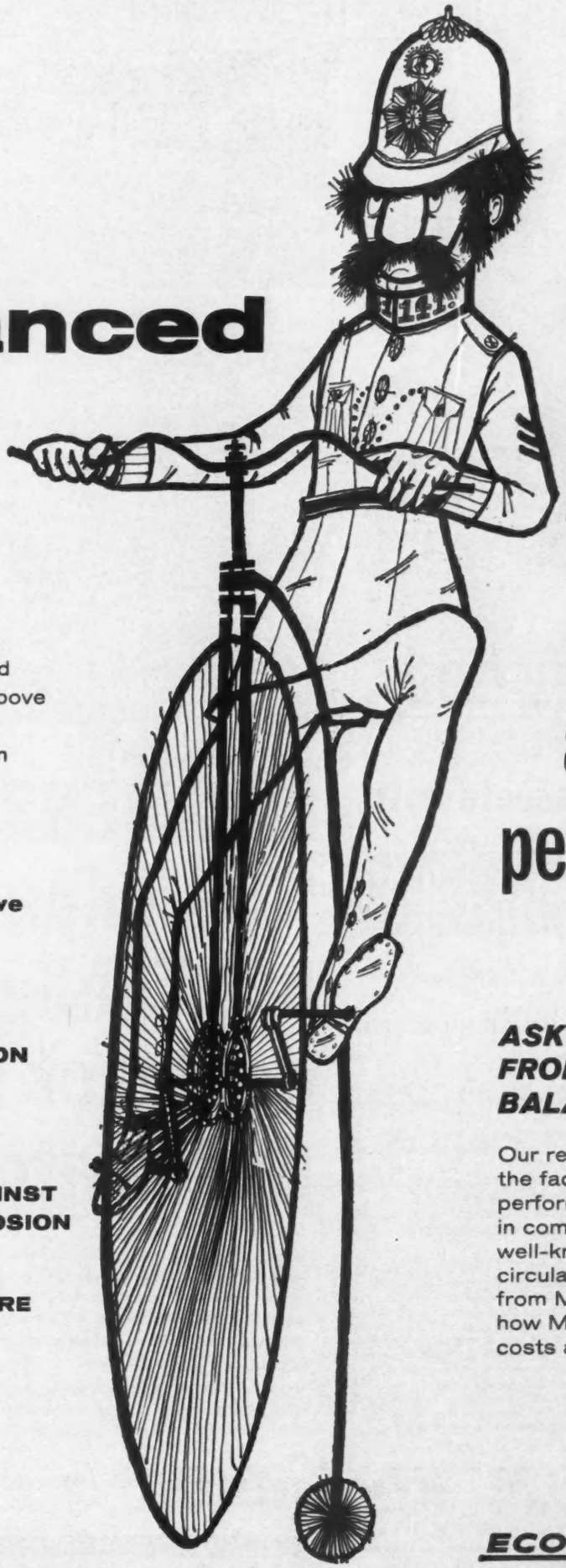

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Mobil D.T.E. Oils stand head and shoulders above all ordinary oils. They give *balanced* protection and performance that no oil on the market today can equal.

Mobil D.T.E. Oils give you the following advantages:

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10 ton Steam Permanent Way Crane. Metre Gauge. Duty: 10 tons at 16 ft. radius propped; 5 tons at 14 ft. radius free.

3 Motor, electrically operated Fixed Wharf Crane. Duty: 15 tons at 22 ft. radius.

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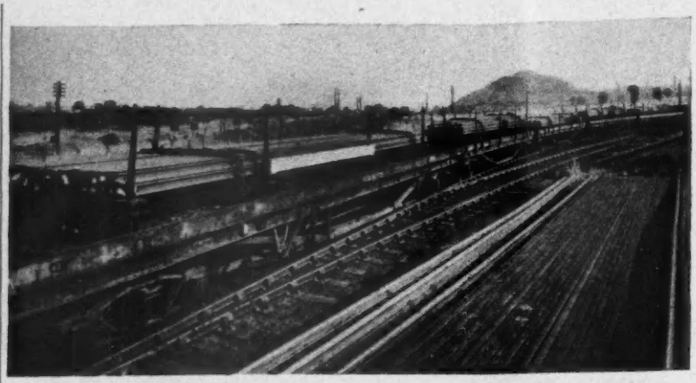

Two train loads of rails and switches leaving Summersons' Spennymoor Works.

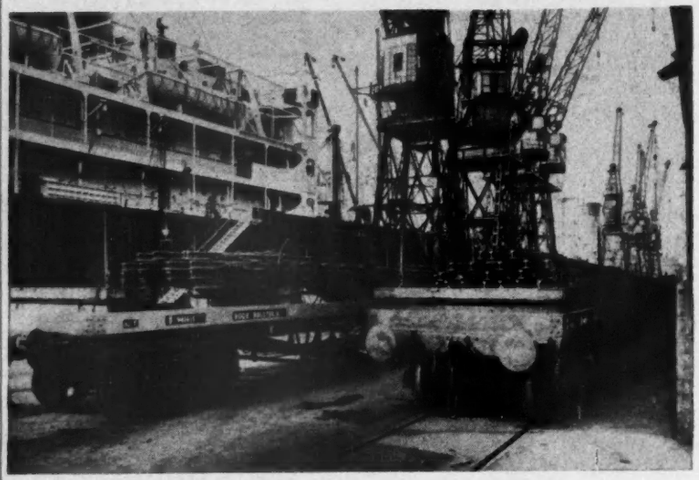

Illustration shows part of two complete trains used to deliver

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There's a size to suit you!

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FIVE DIFFERENT COLOUR FITTINGS, MANY ATTRACTIVE BINDINGS IN SINGLE OR TWO-TONE EFFECTS.

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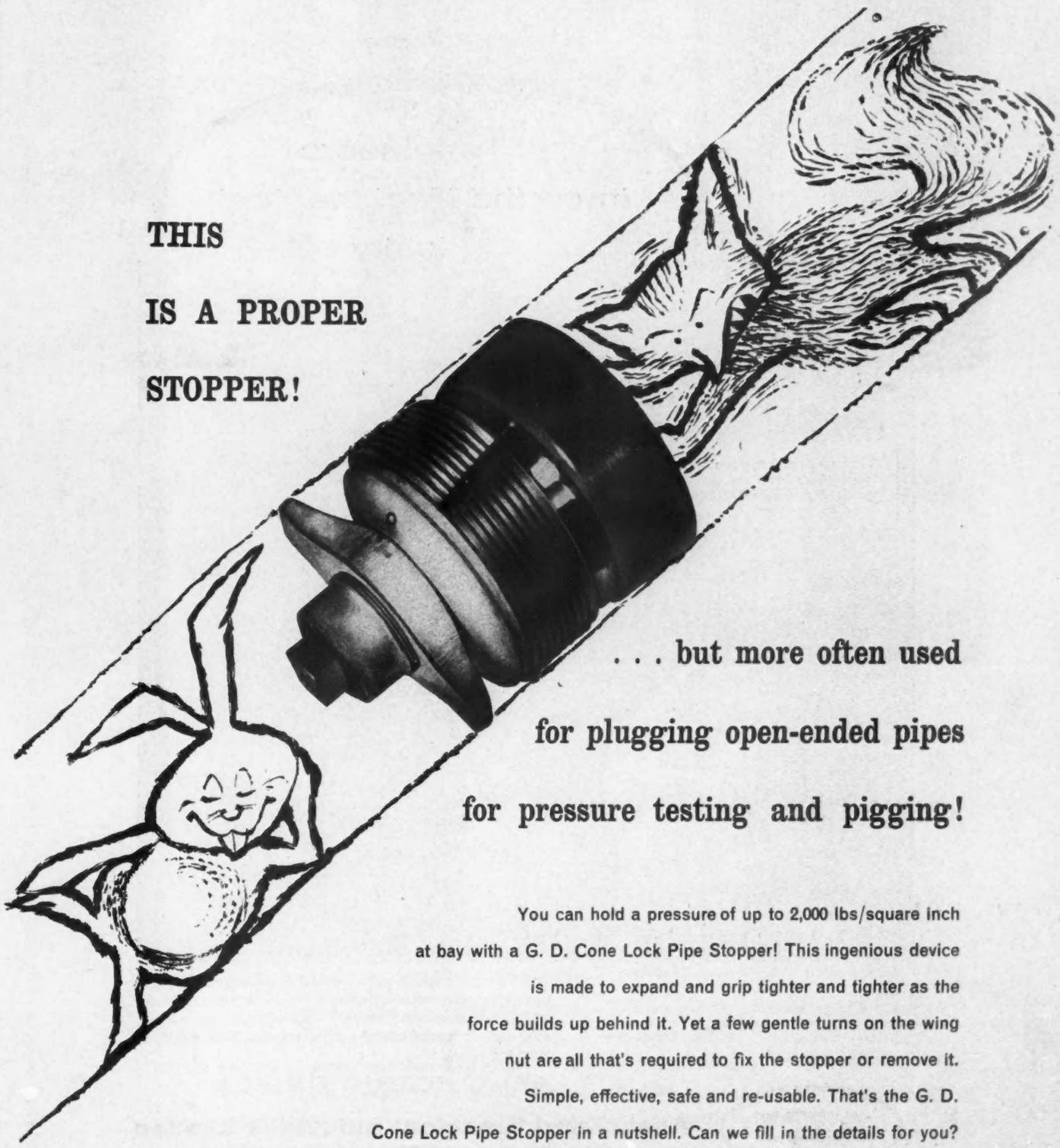

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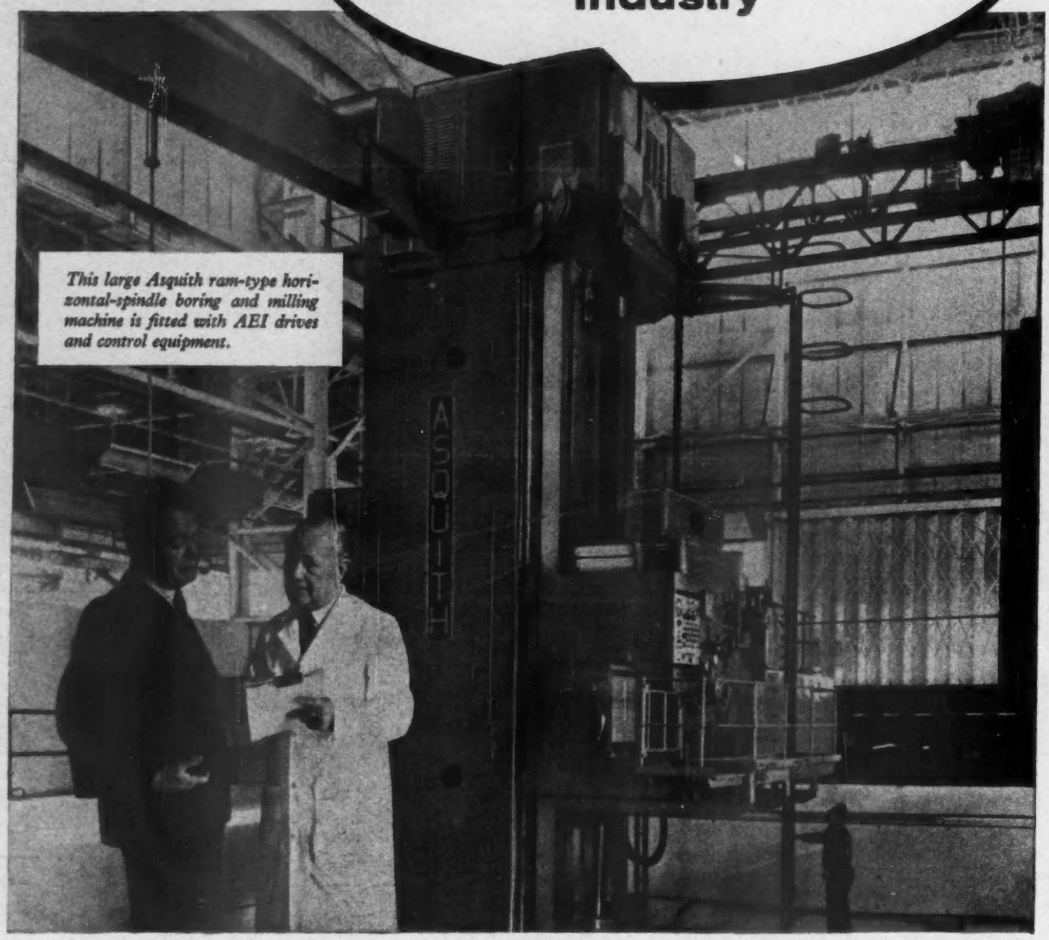

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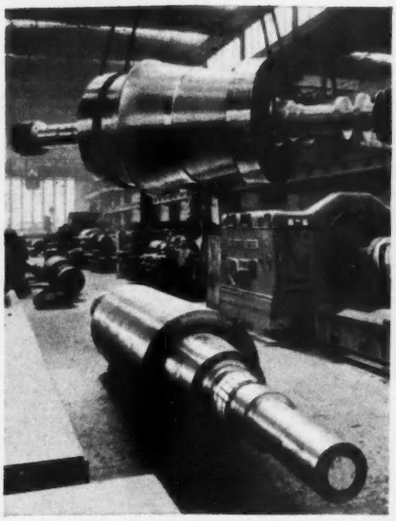
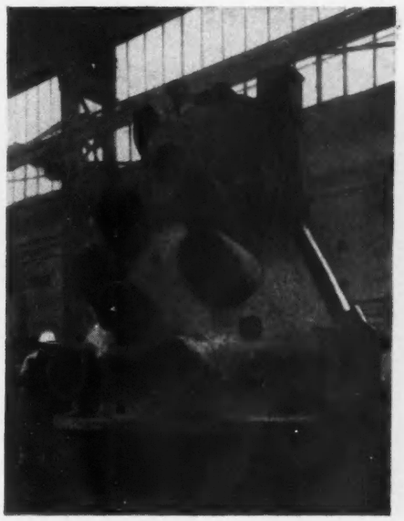
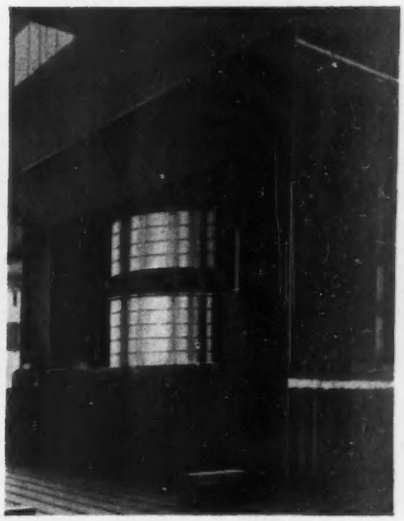
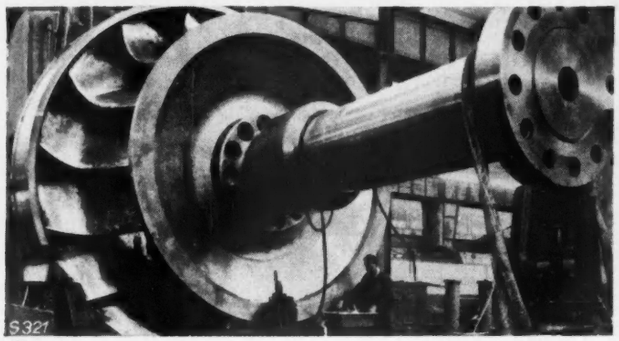

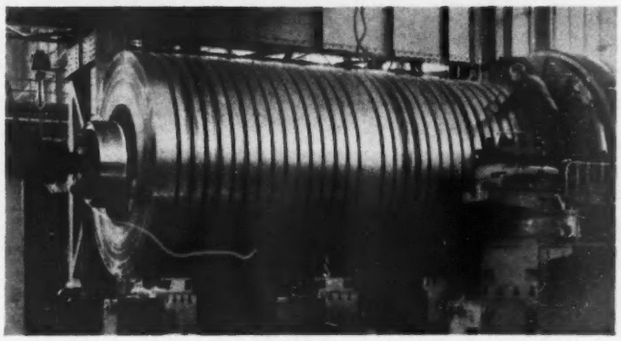

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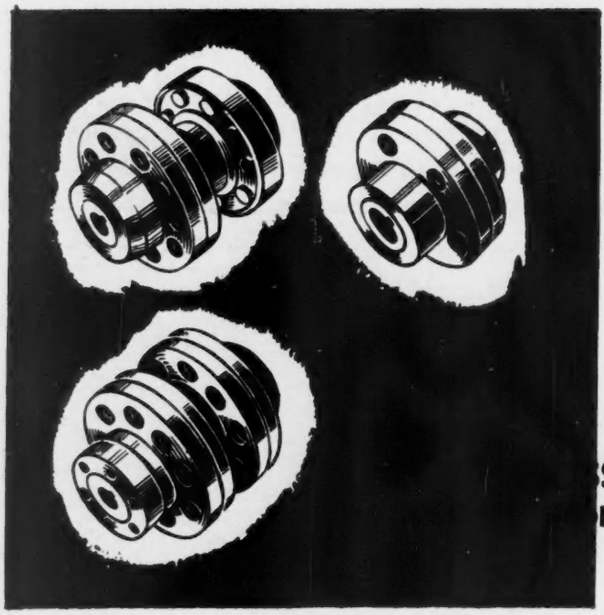

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